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**DEVELOPMENT OF A SYSTEM-WIDE PREDATOR CONTROL PROGRAM:
STEPWISE IMPLEMENTATION OF A PREDATION INDEX PREDATOR CONTROL
FISHERIES AND EVALUATION PLAN IN THE COLUMBIA RIVER BASIN**

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EXECUTIVE SUMMARY

We report our results of studies to develop a Columbia River basin-wide program to control northern squawfish predation on juvenile salmonids. Our studies focus on 1) determining where in the basin northern squawfish predation is a problem, 2) conducting various fisheries for northern squawfish, and 3) testing a plan to evaluate how well fisheries are controlling northern squawfish populations. These studies were initiated as part of a basin-wide effort to reduce mortality of juvenile salmonids on their journey from natal streams to the ocean. Earlier work in the Columbia River basin suggested predation by northern squawfish on juvenile salmonids may account for most of the 10 to 20 percent mortality juvenile salmonids experience in each of eight Columbia and Snake river reservoirs. Modeling simulations based on work in John Day Reservoir from 1982-1988 indicated it is not necessary to eradicate northern squawfish to substantially reduce predation-caused mortality of juvenile salmonids. Instead, if northern squawfish were exploited at a 20 percent rate, reductions in their numbers and restructuring of their populations could reduce their predation on juvenile salmonids by 50 percent. We tested three fisheries in 1990, a tribal long-line fishery, a recreational-reward fishery, and a dam hook-and-line fishery.

The project is a cooperative effort by the Oregon Department of Fish and Wildlife (ODFW), Oregon State University (OSU), the University of Washington (UW), and Computer Sciences Corporation (CSC). ODFW is the lead agency and has sub-contracted various tasks and activities to OSU, UW, and CSC based on expertise each brings to the project. Project objectives of each cooperator are

1. ODFW (Report A): Initiate system-wide, stepwise implementation of a predation index; conduct test fisheries for northern squawfish in John Day Reservoir and at selected, project-specific sites in the lower Columbia and Snake rivers; conduct a test evaluation of a baseline data collection program and of the test fisheries; and synthesize information on predation indexing, the test fisheries and the test evaluation.
2. OSU (Report B): Evaluate the economic effectiveness of test fisheries for northern squawfish in John Day Reservoir and at selected, project-specific sites in the lower Columbia and Snake rivers; evaluate the market potential of alternative northern squawfish products that were not tested during the 1989 pilot fishery; evaluate the requirements and potential for development of a tribal fishery, tribal processing, and tribal marketing of northern squawfish; and evaluate the legal feasibility of test fisheries.
3. UW (Report C): Transfer technology and evaluate effectiveness of that transfer to a subsidized, commercial, limited entry (three vessels) small-boat test fishery for northern squawfish in John Day Reservoir.
4. UW-CQS (Report D): Use the Columbia River Ecosystem Model (CREM) to project multi-season, reservoir-specific salmonid mortality as dependent upon type and amount of predator fisheries and use CREM to project long-term, system-wide salmonid mortality as dependent upon type and amount of predator fisheries and response of predator population to exploitation.

Background and rationale for the study can be found in Report A of this document (Vigg et al. 1990).

Highlights of results of our work by report are

Report A

1. Using CPUE as an index of the population density of northern squawfish, we compared their relative densities in the four lower Columbia River reservoirs; Bonneville, The Dalles, John Day and McNary. Comparisons suggested that in 1990 northern squawfish densities in Bonneville and The Dalles reservoirs were 1.5 to 3.5 times greater than in John Day Reservoir. Northern squawfish density in McNary Reservoir was 0.5 to 0.7 that in John Day Reservoir.
2. Using a morphoedaphic index (MEI) as an index of potential productivity of fish populations, we compared MEI among the four lower Columbia River reservoirs and Ice Harbor tailrace in the Snake River. The tailrace area downstream from Bonneville Dam and McNary Reservoir upstream of the confluence with the Snake River had the highest MEI's, suggesting greater potential productivity there than elsewhere in the lower Columbia River.
3. We captured over 20,000 northern squawfish in the lower Columbia River from April 30 through August 31, 1990. Approximately 10,000 of those were removed from John Day Reservoir. Of the three test fisheries conducted in John Day Reservoir, 47 percent of the northern squawfish harvest was by the recreational-reward fishery, 39 percent by the dam hook-and-line fishery, and 14 percent by the tribal long-line fishery. Harvest in John Day Reservoir was about 12 percent of estimated abundance of predator-sized northern squawfish.
4. The dam hook-and-line fishery was conducted at five dams in the lower Columbia and Snake rivers in 1990; Bonneville, The Dalles, John Day, McNary, and Ice Harbor. Catch per unit effort (CPUE) was highest from McNary Dam tailrace where 5.8 northern squawfish were removed per angler hour. This translated to a total catch of northern squawfish from McNary Dam tailrace of 3,819. Almost 2,500 northern squawfish were removed from Bonneville Dam First Powerhouse forebay where CPUE averaged 2.6 northern squawfish per hour. The only other location where CPUE exceeded 2.0 was in Bonneville Dam First Powerhouse tailrace. Excluding Bonneville Dam, catches from tailraces were three to five times higher than from forebays. Very few species other than northern squawfish were caught by dam anglers; incidental catch was highest at Ice Harbor Dam and consisted mainly of channel catfish.
5. Almost 2,400 recreational anglers registered to participate in the recreational-reward fishery in John Day Reservoir in 1990. About one-third of registrants returned to complete exit interviews. Anglers removed 4,681 northern squawfish from John Day Reservoir from Memorial through Labor days. Two-thirds of the harvest was returned to LePage Park, located on the lower John Day River. Participation and total harvest from mid July through Labor Day was over twice that from Memorial Day through mid July. Participation increased dramatically because the reward was increased from \$1.00 to \$3.00 on July 19. Total harvest increased directly with

participation because CPUE remained relatively constant throughout the season.

6. The tribal long-line fishery harvested 1,420 northern squawfish from John Day Reservoir in 1990. The fishery consisted of three tribal fishermen under contract with ODFW and was conducted from mid June through mid August. Success varied among fishermen; one boat accounted for 48 percent of the harvest. Incidental catch by the long-line fishery consisted of one walleye, eight smallmouth bass, 182 channel catfish, and 269 white sturgeon.

7. We tested various lures trolled from paired down riggers as part of our continuing effort to examine alternative harvesting technologies. Fishing occurred at Bonneville Dam First Powerhouse tailrace and forebay. We harvested 228 northern squawfish and identified four lures as most effective for catching northern squawfish; these lures accounted for 50 percent of the catch, but only 26 percent of the effort. The only incidental catch was one sculpin.

8. Using CPUE observed in each of the fisheries in 1990 and estimates of participation in each fishery based on preliminary plans for 1991 we estimated 250,000 northern squawfish could potentially be harvested in a fully expanded program that includes all eight reservoirs in the lower Columbia and Snake rivers.

Report B

1. Results are not yet available from tests for dioxin accumulation in the flesh and organs of northern squawfish. Estimated completion date for the tests is July 1991.

2. The tribal long-line fishery was operated as a subsidized reward fishery in 1990. Fishermen received a fixed monthly salary and a per-fish reward. This is not how the fishery will operate in 1991 when compensation will be solely on a per-fish reward basis. Direct expenditures related to the operation of the long-line fishery totaled approximately \$40,000, or between \$26 and \$27 per northern squawfish harvested. Approximately 11 percent of total direct expenditures were by the fishermen for gas, food, etc. The remaining 89 percent of total direct expenditures were in the form of bait and gear subsidies, salaries for fishermen and fishery observers, and per-fish rewards. Average net revenues per fisherman for the season were approximately \$6,000. If gear and bait costs were not subsidized and were assigned to the fisherman, net revenues per fisherman would have been half as much or about \$3,000.

3. The recreational-reward fishery involved total direct expenditures for creel clerk wages, uniforms, vehicles, rewards, and miscellaneous supplies and equipment of approximately \$44,400. Recreational-reward fishery participants were surveyed and results presented for two seasonal strata. An "early" season was defined as the period from May 24 through July 18, when the reward was \$1.00 per northern squawfish. A

"late" season was defined as the period from July 19 through September 3, when the reward was \$3.00 per northern squawfish. Angler demographics, fishing methods, expenditures, and level of satisfaction with the fishery were determined.

4. Labor costs per northern squawfish caught by the dam hook-and-line fishery in 1990 ranged from \$4.57 at McNary Dam to \$85.24 at Bonneville Dam Second Powerhouse. Labor costs were the largest component of direct expenditures totaling almost \$151,000. Average expenditures on the dam hook-and-line fishery were almost \$24 per angler hour and \$14 per northern squawfish harvested.

5. The three test fisheries were compared based on their respective economic performance. All three fisheries had costs associated with monitoring activities of participants, providing incentive or compensation for participation, and operations needed to conduct the fisheries. Total direct expenditures per fish harvested for each fishery were \$25.11 for the tribal long-line fishery, \$13.71 for the dam hook-and-line fishery, and \$9.79 for the recreational-reward fishery.

6. Four end uses for northern squawfish were tested in 1990; deboned minced flesh, liquid fertilizer, fish meal, and bait. About 132 kg of round fish yielded 39 kg of minced flesh. Initial feedback from restaurants and markets was favorable for use of minced product by customers. Estimates of wholesale price ranged from \$0.75 to \$1.50 per 600g container of minced product. The oil content of northern squawfish was not sufficient for use by themselves in liquid fertilizer, but processors used them in combination with carp. Processed in large volumes, northern squawfish targeted for liquid fertilizer could be expected to sell ex-vessel at \$0.05 to \$0.10 per lb. Northern squawfish were not deemed suitable for use in liquid fish meal by one processor because they emitted an offensive odor when processed. Other processors will be surveyed. Tests of northern squawfish as crab and crayfish bait indicated they are more suitable as crayfish bait. When the crayfish market is active, northern squawfish may sell at \$0.10 per lb.

7. Responses to a survey to identify legal and regulatory concerns associated with development of a northern squawfish control program indicate

- a. a need to determine effects of full-scale fisheries on incidentally caught fish species, especially salmon and steelhead, and especially in light of recent recommendations to list some populations as threatened under the Endangered Species Act;

- b. a need for review of plans for commercial fisheries between Bonneville and McNary dams by tribal and state managers and governing bodies and formal sanction by U.S. v Oregon parties;

- c. a need for reclassification of northern squawfish by the State of Washington as a food fish;

- d. a need to better define and address regulatory responsibilities and social considerations associated with development of commercial fisheries;

- e. a need to review and interpret regulations by Oregon, Washington and Idaho prohibiting compensation of sport anglers for catch in context of the recreational-reward fishery;
- f. a need to examine effects of issues related to ownership and use of access sites along the Columbia and Snake rivers on participation in the recreational-reward fishery; and
- g. a need to identify and address safety and security issues related to access to federal projects for the dam hook-and-line fishery.

Report C

1. Catch rates for tribal long-line fishermen were lower than predicted, averaging one fish in 22 hooks set. In 1989, catch rates averaged one fish in 12 hooks set. Catch rates among fishermen varied greatly indicating success was dependent upon skill level and effort expended. The more gear set by a fisherman, the higher the catch rate because northern squawfish appeared to move in groups and success depended on increasing the probability of "intercepting" those groups.
2. Fresh and salted salmon smolts appeared to be effective baits for long-lines. Other effective baits were lamprey ammocoetes, sand shrimp, and shad. Sand shrimp and shad had to be specially handled to maintain their integrity.
3. Approximately 15 percent of the long-line catch was white sturgeon. Channel catfish made up an additional 10 percent of the catch. Evaluation of delayed mortality resulting from hooking and handling in the tribal long-line fishery suggested no mortality of white sturgeon and channel catfish held for at least 48 hours. One white sturgeon that swallowed a hook appeared healthy after two days of observation and was released alive.
4. Long-line gear tested in the tribal fishery had two notable problems. Spools used to payout and retrieve gear split under the pressure exerted when lines were retrieved. The manufacturer designed and fabricated heavier spools that proved effective. Hooks quickly became dull and rusted. Use of stainless steel hooks would reduce this problem. However, the persistence of stainless steel hooks would create a more serious problem concerning health of incidental catch that break loose from gear.
5. There were few conflicts between tribal long-line fishermen and other resource users. In an isolated incident, recreational anglers were observed pulling up a long line. The anglers fled when approached by the tribal fisherman. Initial concerns of recreational anglers about negative effects of the long-line fishery on bass, sturgeon and walleye subsided when they were informed that the fishery was closely observed and incidental catch was low was circulated.
6. Tribal fishermen provided constructive feedback concerning conduct of the long-line fishery. Two fishermen suggested using marine sand shrimp as bait. Each expressed concerns about delays in payments for effort and catch; a suggestion was made to develop a system for paying fishermen on site. All called for more flexibility in when and where they could fish; some noted that having to accommodate the schedule of the observers was restrictive.

7. We continued testing the effectiveness of purse seining as a harvest method. We redesigned our 300 x 30-ft purse seine to minimize snagging the river bottom and chartered a 36-ft boat and 600 x 60-ft purse-seine to test commercial-scale gear. We arranged a shut-down of turbines 1 through 4 at McNary Dam to determine effectiveness of using purse-seines to fish northern squawfish populations observed near the powerhouse. We also tested effectiveness of submersed spotlights at night to attract northern squawfish to our boat. Neither purse seine proved effective at catching northern squawfish. We caught one northern squawfish with our seine and 26 with the commercial seine. We were unable to fish near the powerhouse when the turbines were shutdown because gull deflection lines and swift current limited our maneuverability. We did not attract any fish using submersed lights. Results from purse-seining were not conclusive, however. Observations made during seining using the chartered boat suggested that gear could be designed to effectively fish near projects and in the reservoir.

8. We obtained 4,000 lbs of hatchery raised coho salmon smolts as bait for the tribal long-line and dam hook-and-line fisheries. About 3,000 lbs were donated by private growers and 1,000 lbs were purchased from a private grower on a low-bid basis of \$0.05 per smolt. Even though most of the bait was donated, salting and freezing 500 lbs of bait for storage cost about eight hours of staff time, \$30 for food grade rock salt, \$140 for a 1000 lb tote, \$15 for plastic bags, \$15 for flash freezing, and \$7.25 per month for cold storage.

Report D

1. Initial modeling of the effects of harvest of northern squawfish on mortality of juvenile salmonids in John Day Reservoir showed no effects in the first year of the fishery. This is because most of the predators removed were active in the reservoir most of the first year. Effects of harvest first appeared in the year after initiation of the fishery, even if the fishery was discontinued. After five years of continually harvesting northern squawfish from John Day Reservoir, up to a 33 percent reduction in mortality of the most vulnerable salmonids, subyearling fall chinook, occurred.

2. Assuming no population regrowth and sustained fishing for five years, abundance of northern squawfish in the John Day, The Dalles, and Bonneville reservoirs decreased by over 50 percent at the fishing effort observed in 1990, and by over 75 percent at twice the fishing effort observed in 1990. Correspondingly, simulations of predator-caused mortality of subyearling fall chinook decreased by 12 percent at 1990 fishing effort and 41 percent at twice the 1990 fishing effort. Increasing fishing effort to seven times the 1990 level reduced subyearling fall chinook mortality by 89 percent.

REPORT A.

**Development of a System-wide Predator Control Program:
Stepwise Implementation Of a Predation Index, Predator Control Fisheries, and
Evaluation Plan in the Columbia River Basin**

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Deborah L. Watkins was responsible for procurement of supplies and equipment for the 1990 field season. Ruth A. Farr and Kent Anderson were responsible for index field sampling. Daphne Faler, Karen Walker, and Stacie Rimbach assisted with various tasks for preparation of this report, including data summary, typing, and drafting. Over 40 seasonal employees conducted fishing, monitoring, creel, and data collection.

ABSTRACT

We are reporting progress on the northern squawfish *Ptychocheilus oregonensis* predator control study in the Columbia River basin for the period 16 April to 31 December 1990. The purposes of this research are to (1) implement an index of predation on juvenile salmonids by northern squawfish in various reservoirs throughout the Columbia River basin, (2) conduct test fisheries for northern squawfish removal, and (3) develop a plan to evaluate the test fisheries. The goal of the predator control program is to enhance salmon and steelhead populations by reducing predation on juvenile salmonids in Columbia River basin reservoirs.

We sampled with gillnets and boat electrofishers to develop an index of northern squawfish abundance for five reaches of the lower Columbia and Snake rivers. We also collected data on biological characteristics of northern squawfish populations prior to implementation of test fisheries. Results from index sampling indicated that northern squawfish abundance varied among reservoirs; however, catch per unit effort in all reservoirs sampled varied by less than an order of magnitude from John Day Reservoir (50% to 350%). Plans were developed to integrate the abundance index with a consumption index being developed by the U. S. Fish and Wildlife Service so that we may assess the relative predation on juvenile salmonids among reservoirs and specific areas within reservoirs.

We conducted three test fisheries in 1990 to test the hypothesis that through sustained (> 5 years) fishery harvest of northern squawfish resulting in 10-20% exploitation, predation on juvenile salmonids could be reduced by half. These fisheries included (1) agency technicians angling from five mainstem dams in the Columbia and Snake rivers, (2) a public sport-reward fishery in John Day Reservoir, and (3) a tribal commercial longline fishery in John Day Reservoir. We also conducted a study to evaluate the feasibility of collecting northern squawfish by trolling lures.

We harvested 11,005 northern squawfish by dam angling, 4,681 in the sport-reward fishery, 1,420 in the commercial longline fishery, and 228 by trolling lures. These results demonstrated that it was feasible to remove 10-20% of the northern squawfish population in John Day Reservoir using fisheries. As a result, plans were developed to expand the scope of the predator control program beyond John Day Reservoir in 1991. Based on catch rates we observed in 1990 applied to full scale implementation in the lower Columbia and Snake rivers in 1991, we project a total potential harvest of about 244,000 northern squawfish: 52,000 by dam angling, 171,000 in the sport-reward fishery, and 21,000 in the commercial longline fishery.

We developed an evaluation scheme for the predator control program that entails (1) evaluating the efficacy of each fishery by comparing catch rates and size composition of northern squawfish and catch of non-target species among fisheries, (2) sampling northern squawfish to determine if, as hypothesized, the fisheries restructure the northern squawfish populations to consist of smaller, less predacious individuals, and (3) evaluating northern squawfish biological data to determine if populations somehow compensate to reduce the effects of the fisheries.

INTRODUCTION

Relationship to the Columbia River Basin Fish and Wildlife Program

Mortality of juvenile salmon and steelhead migrating downstream through the Columbia River system is a major concern of the Columbia Basin Fish and Wildlife Program (NPPC 1987). As outlined in the program, reservoir mortality is an area of emphasis for Bonneville Power Administration (BPA) funding (NPPC 1987, Section 206(b) (1)(A)). Predation is an important component of mortality of juvenile salmonids migrating through the Columbia River system, and northern squawfish *Ptychocheilus oregonensis* are important predators (NPPC 1987, Section 401). There is general agreement that downstream passage and survival of juvenile salmonids are adversely affected by seasonally altered and low flows caused by the hydropower system increasing their exposure to predators (NPPC 1987, Section 301). The technical work group on reservoir mortality and water budget effectiveness (NPPC 1987, Section 206(b)(2)) has supported continued research and implementation of control measures to help alleviate the predation problem. Northern squawfish control is an important part of BPA's strategy to enhance stocks of salmonids which are being considered for federal listing as threatened or endangered (Stephen Smith, BPA, Personal Correspondence).

Background

Development of the Columbia River basin hydroelectric system has created impoundments throughout the basin and enabled establishment and enhancement of resident fish that prey on downstream migrating juvenile salmonids. The hydropower system has exacerbated the problem of predation-related mortality of juvenile salmonids in the Columbia River because impoundments have delayed migratory travel time, resulting in prolonged exposure (Raymond 1988). Recent studies (Poe and Rieman, editors 1988) have indicated that predation-caused mortality of juvenile salmonids is significant in John Day Reservoir. Northern squawfish were the most abundant predator (Beamesderfer and Rieman 1988), had high consumption rates on juvenile salmonids (Vigg et al. 1988), and accounted for about 80% of the total predation losses in John Day Reservoir (Rieman et al. 1988). On a smaller scale, various studies (Sims et al. 1978, Uremovich et al. 1980) indicated that local concentrations of northern squawfish in tailraces and forebays of Columbia River basin dams can be great. These results are consistent with previous studies in the Columbia River basin that showed northern squawfish to be an important predator of juvenile salmonids (Zimmer 1953, U.S. Fish and Wildlife Service (USFWS) 1957, Thompson 1959, Thompson and Morgan 1959). Poe et al. (1988) reviewed the literature describing various measures that have been used to control predator populations and identified those measures that had the greatest potential for success in the Columbia River. Modeling simulations of reservoir-wide potential predation in John Day Reservoir indicated that it is not necessary to eradicate northern squawfish in order to substantially reduce predation mortality, but that about 20% exploitation of the northern squawfish population by a sustained fishery could reduce juvenile salmonid losses to predation about 50% (Rieman and Beamesderfer 1990).

Predator Control Fishery Development Strategy

Previous predator control fishery development research, conducted during 1988-1990, provided an institutional regulatory review pertaining to fishery development, evaluation of economics of various types of fisheries, evaluation of commercial fishery harvest technology, and development of a conceptual plan for a step-wise process for the systematic implementation and evaluation of commercial, sport-reward, and dam angling fisheries on northern squawfish (Nigro, editor 1989). A plan is necessary for the orderly development of commercial, sport, or bounty fisheries on northern squawfish throughout the Columbia River basin. Decisions must be made to define the scope of the system-wide predator control program, and to determine how and where to implement the predator control fisheries initially as a test fishery in 1990 with large-scale implementation beginning in 1991 (Figure 1). We are defining "system-wide" as the mainstem Columbia River from Bonneville Dam tailrace to Chief Joseph Dam, and the lower Snake River to Hells Canyon Dam. To proceed with predator control fisheries in a logical and systematic manner, two hypotheses must be tested: (1) fisheries can effectively exploit northern squawfish populations and thus reduce predation, and (2) predation is a significant source of juvenile salmonid mortality in various reservoirs throughout the Columbia River system. Test fisheries in John Day Reservoir and an evaluation of those fisheries were designed to address hypothesis (1), and a predation index was designed to address hypothesis (2).

An evaluation is essential for scientific management of northern squawfish control fisheries. Implementation and evaluation of test fisheries in 1990 provides a realistic foundation for a comprehensive predator control program that incorporates evaluation as an integral component. Monitoring northern squawfish populations and ongoing development of predator-prey modeling will help us to understand the dynamics of predation and predict possible consequences of predator removal.

There is general consensus that predation is a significant problem in John Day Reservoir, but the significance and dynamics of predation are still unknown in other reservoirs in the Columbia River basin. Information is needed to estimate the relative importance of predation by northern squawfish throughout the mid and lower Columbia River and lower Snake River reservoirs, and determine if and where predation control measures should be applied. The cost, time, and uncertainty of absolute predation loss estimates as conducted in John Day Reservoir (Rieman et al. 1988) are prohibitive to conduct in each reservoir in the system. A rapid assessment predation index was developed to provide a less costly way to determine if the magnitude of fish predation in other Columbia River basin reservoirs is similar to that in John Day Reservoir (Vigg and Burley 1990).

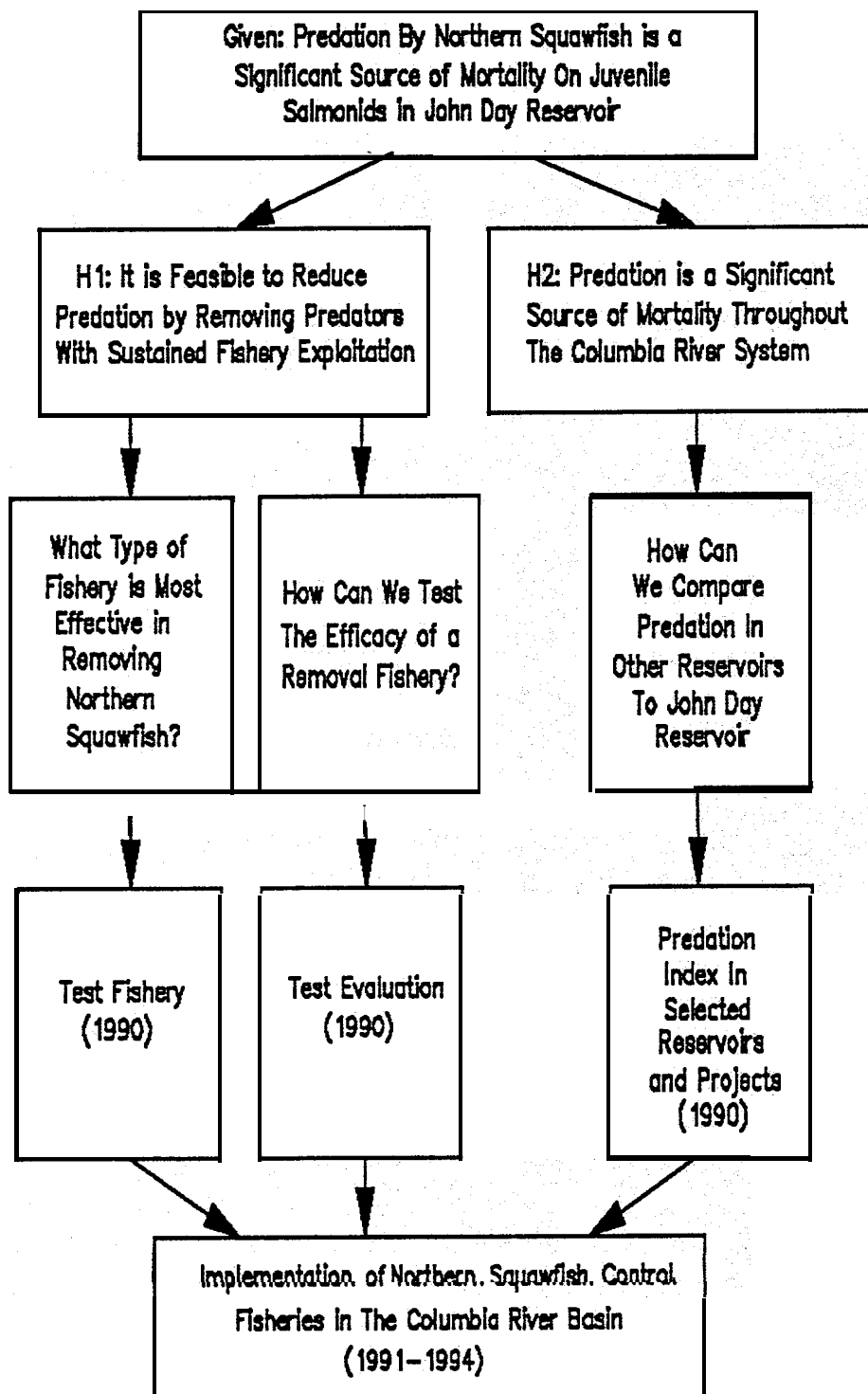


Figure 1. Logic pathway for testing hypotheses necessary for planning system-wide fishery implementation in the Columbia River Basin, beginning in 1991.

Goal, Objectives, and Approach of the 1990 Predator Control Program

The goal of predator control is to reduce in-reservoir mortality of juvenile salmonids due to predation by northern squawfish. The primary anticipated benefit is a 50 percent reduction of predation on downstream migrating juvenile salmonids. Additional benefits will be to better understand the predator population dynamics affecting salmonid mortality processes, to predict the magnitude of predation mortality under different conditions, and to provide information for fishery managers to evaluate actual success and benefits of the predator control program. The objectives of this project are to (1) determine the significance of predation in Columbia River reservoirs through indexing of predator abundance and integration with consumption indices, (2) implement a predator control fishery development plan, beginning with test fisheries in the John Day Reservoir in 1990, and (3) initiate an evaluation of the predator control program. In order to meet these objectives we have developed three research approaches: predation indexing, test fisheries, and test fisheries evaluation.

Predation Index

The predation index provides a relatively inexpensive way to estimate the magnitude of fish predation in various reservoirs in the mid and lower Columbia and lower Snake River reservoirs relative to John Day Reservoir. The predation index is intended to direct the implementation of the predator control program in a measured and systematic way throughout the Columbia River basin. The three main-stem reaches being considered are the lower Columbia River (Bonneville Dam tailrace to McNary Reservoir), the mid-Columbia River (Hanford Reach to Chief Joseph Dam tailrace), and the lower Snake River (Ice Harbor Dam tailrace to Hells Canyon Dam tailrace). Conceptually, the predation index (PI) for northern squawfish in Columbia River reservoirs will be a product of a predator abundance index (A) and a consumption index (C):

$$PI = A \cdot C$$

The components of the predation index and the method for integrating them are currently being developed. The Oregon Department of Fish and Wildlife (ODFW; BPA Project 82-012) investigated various methods which could be used for predator abundance indexing, including catch per unit effort and morphoedaphic index (Vigg and Burley 1989, 1990). The USFWS (BPA Project 82-003) is developing methodology for consumption rate indexing including bioenergetics modeling and stomach contents analysis (Petersen et al. 1990).

The specific objectives of implementing a predation index were:

1. To assess the magnitude of predation in various reservoirs throughout the Columbia River Basin relative to the baseline data in John Day Reservoir.
2. To direct the predator control fishery to the sites and reservoirs, on a priority basis, to the places where the predation problem is the greatest.

Test Fisheries

The purpose of test fisheries is to determine the types of fisheries (dam angling, sport-reward, or commercial longline) most effective in removing northern squawfish (Figure 2).

The specific objectives of the 1990 test fisheries were:

1. Concurrently implement three control fishery approaches in John Day Reservoir (dam angling, sport-reward, and commercial longline) to test their relative efficacy in removing northern squawfish.
2. Implement dam angling at other project-specific "hotspots" in conjunction with the predation index (John Day, Bonneville, The Dalles, McNary, and Ice Harbor dams).
3. Provide technology transfer of the commercial fishing methodology proposed by the current harvest technology study.

Test Fisheries Evaluation

The purpose of the test fisheries evaluation is to test the plan for economic and biological evaluation of predator removal. A primary objective of the previous planning study (BPA Project 82-012) was to develop a strategy for evaluation of the efficacy of the predator control program (Vigg and Burley 1989). There are three possible levels of evaluation to predict and quantify the effects of the control fishery (Figure 3): (1) northern squawfish population structure and abundance (and associated fish community interactions), (2) survival of juvenile salmonids, and (3) ultimately, adult salmon and steelhead returns. Effects on the northern squawfish population will be monitored from statistics derived from the control fishery (catch per unit effort (CPUE) and size structure). Modeling will be used to simulate the secondary effects on the resident fish community, potential compensatory mechanisms, and the ultimate effects on juvenile salmonid survival. Long term monitoring (10 to 50 years) of adult salmonid returns would be needed to attempt to assess the ultimate effects of a predator control program. Even then it probably would not be possible to isolate the individual effects of various concurrent enhancement measures.

The specific objectives of the 1990 test evaluation were:

1. Test the economic evaluation plan in John Day Reservoir and at project-specific sites prior to large-scale control fishery implementation; economic evaluation data will be used to monitor fishery performance and prospects for long-term sustainability (Hanna 1990).
2. Test the biological evaluation plan in John Day Reservoir, in other specific reservoirs, and at specific projects prior to large-scale control fishery implementation; biological evaluation will include collecting pre-treatment baseline biological data on predators, monitoring of catch and size composition data in each fishery, and utilization of this information to project changes in predator populations and resultant reductions in salmonid mortality via the predator control simulation model.

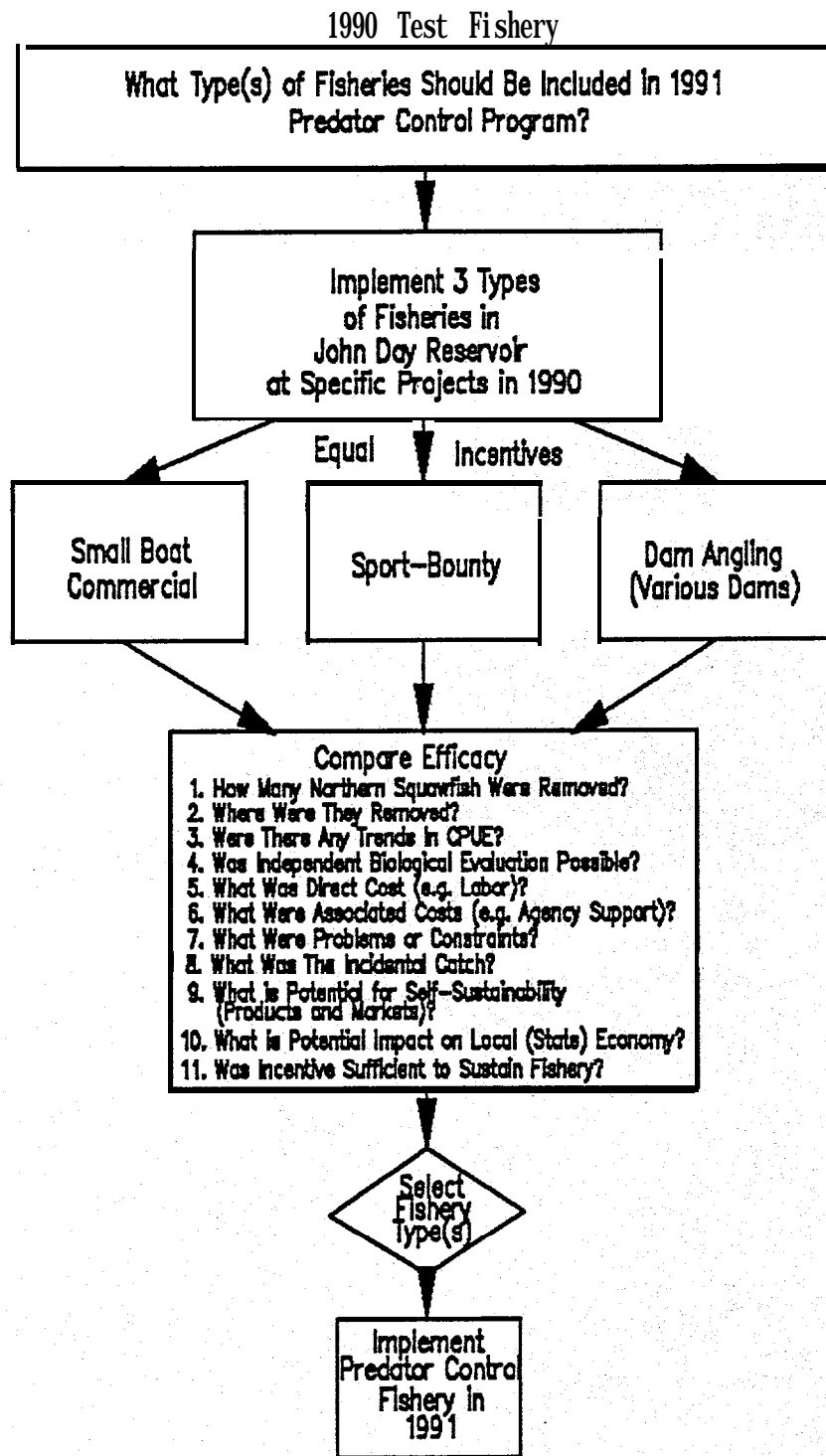


Figure 2. Components of the 1990 test fishery and criteria for selection of which fishery type(s) to incorporate into the predator control program.

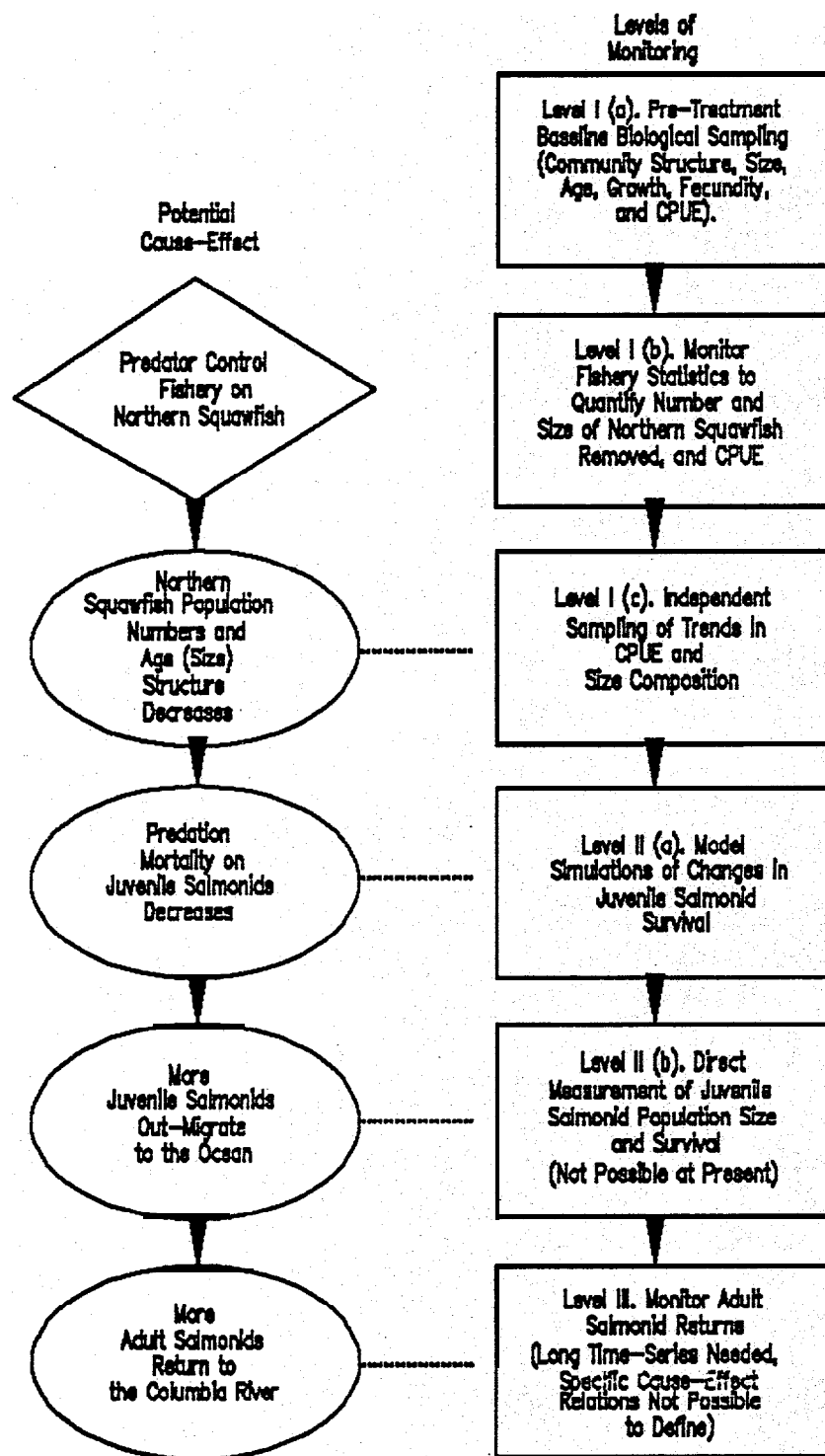


Figure 3. Three possible levels of biological evaluation of predator control fisheries.

METHODS

Field Procedures

Predator Abundance Index Sampling

We used bottom gillnets, surface gillnets, and an electrofishing boat to collect northern squawfish in Bonneville Dam tailrace, Bonneville Reservoir, The Dalles Reservoir, John Day Reservoir, McNary Reservoir, and Ice Harbor Dam tailrace from May through September (Figures 4 and 5). Gillnetting was conducted by two ODFW crews, whereas electrofishing was conducted by one ODFW and one USFWS crew. Sampling effort was stratified by time and location to achieve a representative sample while maximizing the total number of samples. Each crew sampled for two days in three areas per reservoir (forebay, mid-reservoir, and tailrace) during two segments of the juvenile salmonid out-migration: early (May-July) and late (July-August). Each reservoir area (and Bonneville Dam and Ice Harbor Dam tailraces) was subdivided into numerous transects of approximately equal size (Appendix A). ODFW sampling for each period started at Bonneville Dam tailrace and progressed upriver to Ice Harbor Dam tailrace. Conversely, USFWS sampling started upriver and progressed down river.

Each two-person electrofishing crew used an 18-ft aluminum electrofishing boat and worked four, 10-hour days per week. An electrofishing unit of effort consisted of a 15-minute run with continuous output of approximately 5 amperes. Sampling was initiated 2 hours prior to daylight. A minimum of six randomly assigned transects were sampled each day.

A two-person crew operated each gillnet boat and worked four, 10-hour days per week. Bottom and surface gillnets were 45.6-m long, 2.4-m deep, had a foam core float line and 30-lb lead line, and were constructed with two halves, each with three 7.6-m panels of 3.2, 4.4 and 5.1 cm bar mesh, respectively. The surface gillnets also had 11.5 by 7.1 cm floats spaced every 61 cm for buoyancy. The unit of effort for gillnetting was a one-hour net set. Sampling started at dawn and each crew set both a bottom and a surface net in three randomly assigned transects each day.

Data collected from each electrofishing run and gillnet set included date, start and stop time, minimum and maximum depth, location, species of fish caught, fork length (mm), weight (g), condition of fish at capture, fish disposition, if scale sample taken, sex, maturity (if fish sacrificed), tag color and number (if present), secondary mark (if present and missing a tag), and gonad weight (± 0.1 g). From early June through July, the entire gonads were removed from female fish determined to be ripe. After being weighed, female gonads were placed in jars and preserved in Gilson's solution for later fecundity determinations.

Morphoedaphic Index

Morphoedaphic Index (MEI) is the seasonal average total dissolved solids (TDS) divided by mean reservoir depth (z). We collected monthly (June-August) water samples in areas we conducted electrofishing and gillnet sampling for subsequent analysis of total dissolved solids (TDS). Water samples were collected at mid-reservoir or tailrace at a depth of approximately 0.5 m.

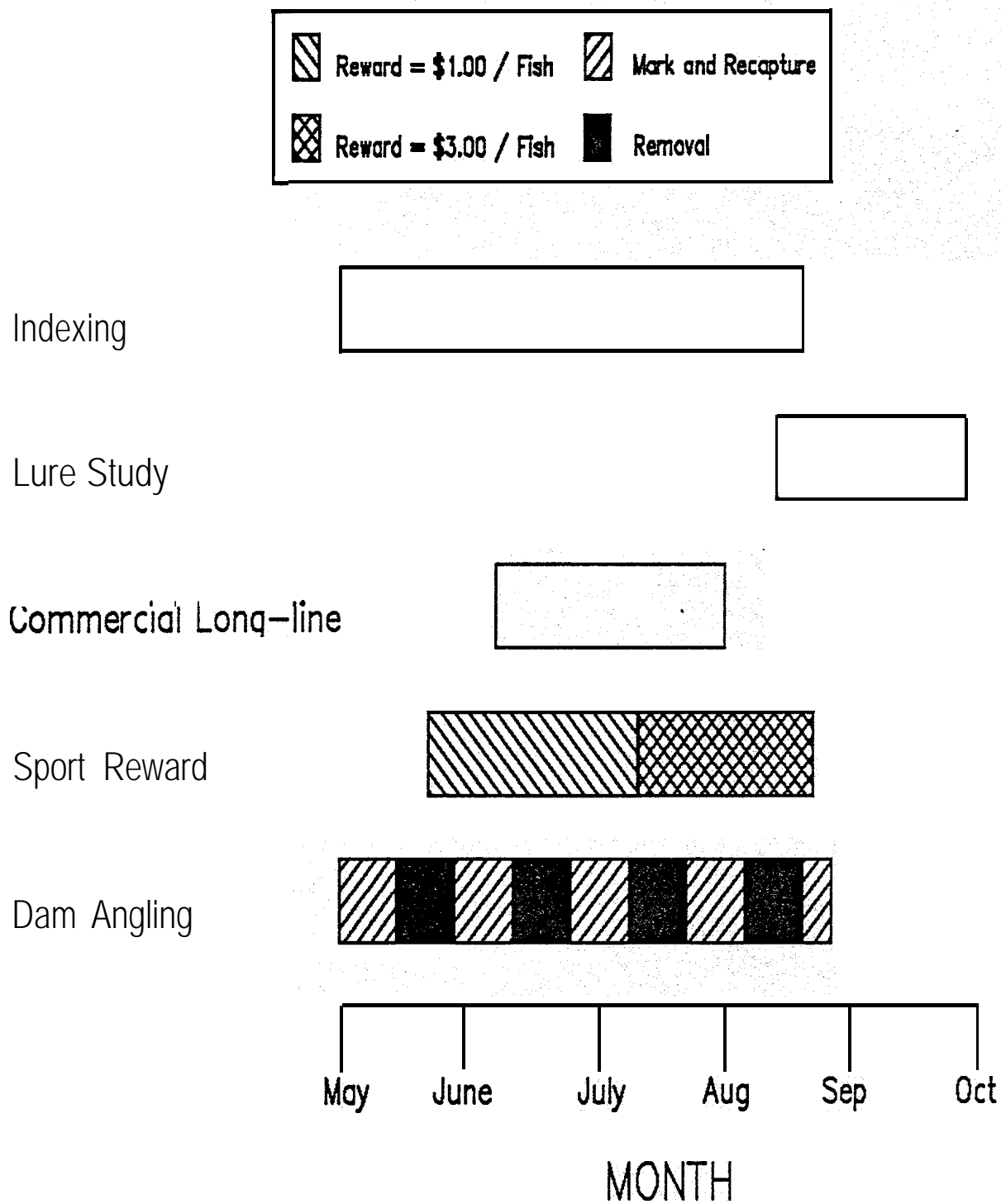


Figure 4. Timing of index sampling and test fisheries during 1990.

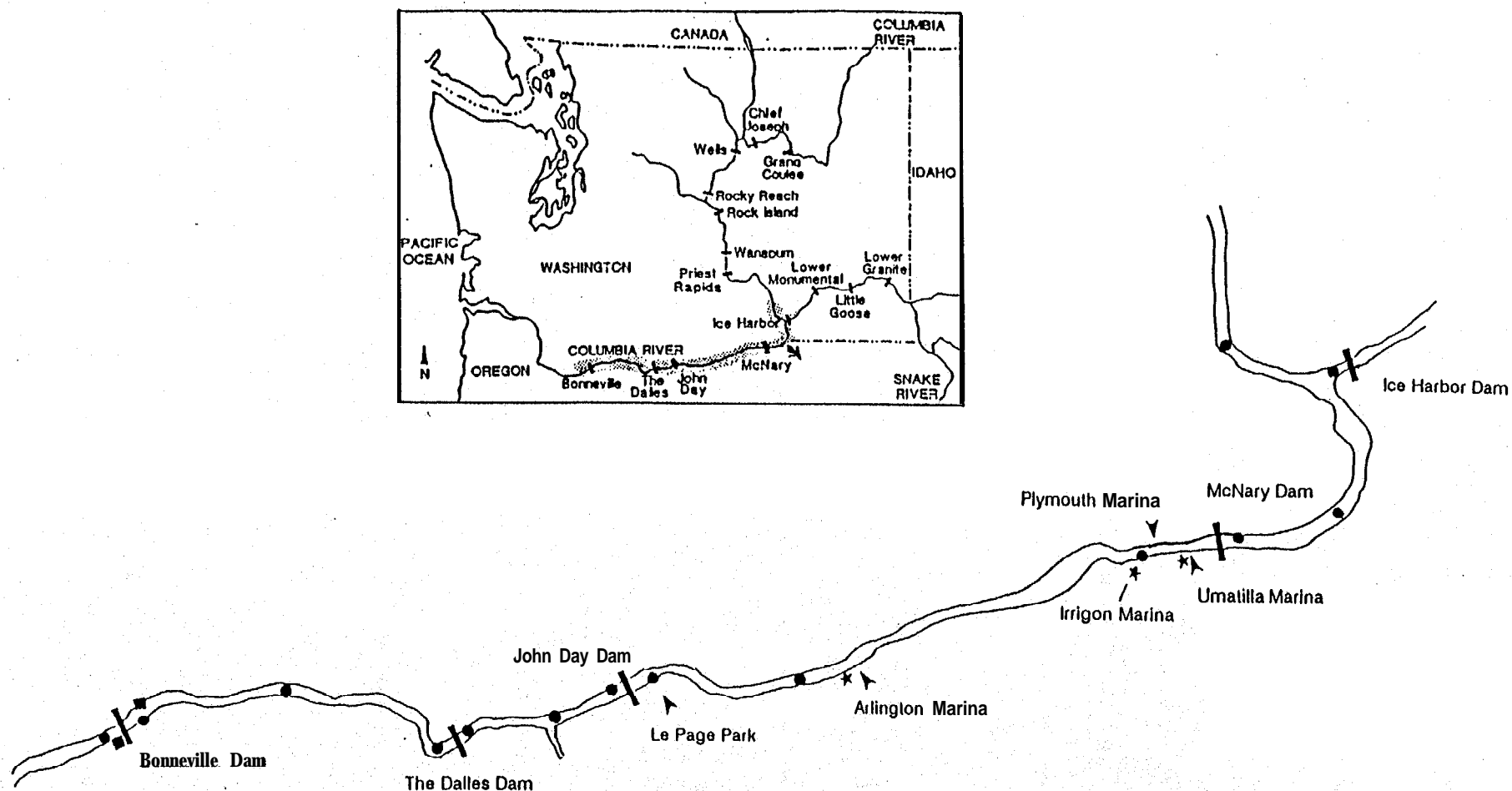


Figure 5. Index sampling and test fisheries locations in the lower Columbia and Snake rivers during 1990. ■ = lure study stations, ● = index sampling stations, ▲ = sport-reward access points, and ★ = commercial longline fishery access points. Dam angling was conducted at each of the five dams.

Dam Angling

Dam angling was conducted from April through August 1990 at five hydropower projects on the lower Columbia and Snake rivers: Bonneville, The Dalles, John Day, McNary, and Ice Harbor dams (Figures 4 and 5). Two crews of two people each fished eight hours a day, five days a week at each project. Two-week periods in which fish were marked and released alternated with two-week periods in which fish were removed (Figure 4).

The standard unit of dam-angling effort was one hour of fishing (timed using a stop watch). Only the actual process of fishing was included in this hour (baiting the hook, retying tackle, casting, hook in the water, and reeling in fish). Other actions (transferring fish from fishing area to holding area and breaks) were not. During each hour of fishing effort, fishing location and bait type were held constant. As fish were caught they were placed into 5 gallon buckets. After three fish were caught, or after 10 minutes, fish were transferred to a 4' x 4' x 3' holding tank. During hot weather, each fish was placed directly into the holding tank. Data collected for fishing effort included angler name, date, dam, location on dam, bait type, start time, stop time, number of northern squawfish caught, and number of other species caught.

Two rod and reel types were used during the study. An electric reel and stout rod were used at the tailrace areas where the bait could be lowered down to the water and carried away from the project by the current. A spinning reel and medium action rod were used at the forebay areas to cast the bait away from the project and retrieve it as it floated toward the dam. Rotation of the crews was necessary to reduce wrist fatigue from reeling in fish for extended periods of time at the forebay areas.

After one hour of fishing effort, biological data were collected from the fish caught and recorded on a processing data form. During the mark and release periods, data collected from the individual fish included fork length (mm), weight (g), condition of the fish, fish disposition, if a scale sample was collected, tag color, tag number, if the fish had a secondary mark, and if it was used for the handling mortality study. During the removal period, data collected from the individual fish included fork length (mm), weight (g), condition of the fish at capture, fish disposition, scale sample, sex, maturity, tag color, tag number, secondary mark, and gonad weight (within 0.1 g). If more than 20 fish were caught during the removal period in one hour, the catch was subsampled by processing every 4th fish with the exception that all fish collected were measured for length and a scale sample collected. During the mark and release periods, the marked fish were allowed to recover in the holding tanks for one hour prior to release. Fish that did not recover were recorded as immediate mortalities.

A variety of artificial lures were tested to determine their effectiveness at catching northern squawfish at the dams (Table 1). Lures were randomly assigned times and days to be tested. Artificial lures were tested by each crew at each dam from July through August. At the start of a one hour fishing session, one member of the two person crew fished with the test lure and the other person fished with standard bait (juvenile salmonids). After one hour, crew members switched poles for the next hour.

Table 1. List of artificial lures used for dam angling.

Lure Type	Code
Mepps, Comet Mino #2, (1/4 oz.)	9001
Luhr Jensen, Metric #6, (3/8 oz.)	9002
Luhr Jensen, Pro Lure, yellow/orange dots, (1/3 oz.)	9003
Luhr Jensen, Pro Lure, grasshopper, (1/4 oz.)	9004
Luhr Jensen, Pro Lure, nickel, (3/4 oz.)	9005
Luhr Jensen, Salmon Seeker, chrome, (2", 1/9 oz.)	9006
Luhr Jensen, Krocodile #4, chrome, (5/8 oz.)	9007
Luhr Jensen, Shyster, fire/black dot, (1/3 oz.)	9008
Luhr Jensen, Pro Lure, fire/hammered brass stripe (1/4 oz.)	9009
Luhr Jensen, Pro Lure, fire/hammered nickel strip (1/4 oz.)	9010
Luhr Jensen, Bang Tail, bronze/green hackle, (1/4 oz.)	9011
Luhr Jensen, Mister J, chrome, (1/2 oz.)	9012
Luhr Jensen, Needlefish, nickle, (1/3 oz.)	9013
Luhr Jensen, Flutter Spoon, nickle/horiz. lines (1/4 oz.)	9014
Luhr Jensen, Flutter Spoon, nickel/vert. lines (1/3 oz.)	9015
Lape's, Down and Dirty floating rig, gold (1.0 oz.)	9016
Luhr Jensen, Tee-Spoon, nickle, (1/3 oz.)	9017
Luhr Jensen, Tee-Spoon, brass, ((1/3 oz.)	9018
Luhr Jensen, Crippled Herring, chrome, (3/4 oz.)	9019
Luhr Jensen, Crippled Herring, blue/chrome, (3/4 oz.)	9020
Luhr Jensen, Hot Shot #30 rainbow	9021
Luhr Jensen, Hot Shot #30 fire	9022
Luhr Jensen, Hot Shot #30 chrome	9023
Les Davis, Bang Tail, shrimp scale, (1/4 oz.)	9024
Les Davis, Bang Tail, chartreuse/black scale, (1/4 oz.)	9025
Luhr Jensen, Kwikfish, silver shad, #K12	9026
Luhr Jensen, Kwikfish, orange/black, #K12	9027
Luhr Jensen, Kwikfish, rainbow trout, #K12	9028
Mann' Angler Twin, red, 3/0 mustad 92641	9029
Bass Pro Shop, white shrimp, 3/0 mustad 92641	9030
Mann's Angler Twin, brown, 3/0 mustad 92641	9031
Mann's Angler Twin, green, 3/0 mustad 92641	9032

To evaluate mortality of northern squawfish due to tagging and handling, we conducted handling mortality tests from July through August, when temperatures were highest. During each day of the mark and release period, a maximum of two marked fish from each hour at each site were randomly removed and placed in the holding tank for the study. Makeup water was added to the tank at a rate of 1 liter per minute. Dissolved oxygen was added to the tank, and water temperature was recorded. After a minimum of 24 hours, fish were checked for condition, mortalities were counted, and surviving fish were returned to the river.

Sport-Reward Fishery

A public reward fishery was implemented on 24 May at four access points in John Day Reservoir: Plymouth Marina, Umatilla Marina, Arlington Marina, and LePage Park (Figures 4 and 5). Three of the access points were maintained through the entire field season, 24 May to 3 September. Access points were staffed 4 days a week (Thursday-Sunday) and holidays from 6 AM to 3 PM with a bounty of \$1.00 paid for each northern squawfish greater than 11 inches total length. The fishery hours and bounty reward were changed on 19 July to 15 hours per day (6 AM to 9 PM) and \$3.00 per northern squawfish. At this time the Arlington Marina fishery was terminated due to lack of participation.

At each access point, a creel clerk registered each fisherman or group of fishermen for the sport-reward fishery before they started fishing for northern squawfish. Initial information collected from participants included angler's name, sex, telephone number, best contact time, fishing license number, species targeted, if the angler was fishing from a boat or the bank, date, and start time. Upon returning, anglers were given an exit interview. Data collected at this time included return time, total time out, number of anglers participating, number of hours actually fished, location(s) fished, type of bait or tackle used, number of northern squawfish returned, and number of tagged northern squawfish caught.

Successful anglers were issued a voucher for the reward amount. The voucher contained a series of questions to evaluate the sport-reward fishery in terms of economic and social parameters. The voucher was either completed at the access point and given to the creel clerk or was filled out later by the angler and mailed to the Portland ODFW office for processing. The deadline for submitting completed vouchers for payment was 30 September 1990. Data collected from vouchers included number of anglers in the fishing party, number of hours spent fishing, total years the angler has spent fishing the reservoir, total miles traveled one way to participate in the sport reward fishery, accommodations stayed at if the angler stayed overnight, amount spent on accommodations, cost of other expenditures, type of fishing method(s), type of bait or tackle used, cost of tackle, number of northern squawfish returned, number of other fish species caught, opinion of the fishing experience, if the angler had fished for northern squawfish before, if the angler had caught northern squawfish previously while fishing for other species of fish, what was done with the northern squawfish that were caught in the past, if the angler had eaten northern squawfish, and if the angler had eaten northern squawfish, how was the quality of the fish, number of fishing trips made per year, did the angler plan to fish for northern squawfish again during the summer, in general what species of fish did the angler normally fish for in each of the four seasons, what state did the angler reside in, age of the angler(s), and type of problems encountered with other fishermen.

Biological data were collected from the fish turned in to the creel clerk and the fish were then either given to the angler with the caudal fin removed or kept by the creel clerk. Data collected from individual fish included fork length (mm), fish disposition, tag color (if present), tag number (if present), if a secondary mark was present and tag absent, and total weight of the northern squawfish catch (lbs).

Commercial Longline Fishery

A commercial longline fishery was implemented as a special services contract to Indian fishermen. The fishery was open to eligible tribal members on a competitive basis. Three fishermen (with boat and crew) were selected. The fishery was conducted from 12 June through 9 August at three access points on John Day Reservoir: Umatilla Marina, Irrigon Marina, and Arlington Marina (Figures 4 and 5). The commercial fishery schedule was 4 days per week and 10 hours per day.

One ODFW technician was stationed on each of the longline boats to monitor the commercial fishery. Observers collected data from the catch such as location, bait type, date, number of hooks set, start and stop times, minimum and maximum depth of the set line (m), number of hooks retrieved without fish but having bait, number of hooks without fish or bait, number of broken or lost hooks, species of fish caught, fork length (mm), weight (g), condition of the fish at capture, fish disposition, if a scale sample was collected, sex, maturity, tag color (if present), tag number, secondary mark (if mark present or not, and the fish was missing a tag), gonad weight (± 0.1 g), hook location (position on fish). Each observer also collected economic data including date, time spent on the water, time spent off water, time spent on gear maintenance, total number and weight of each species of predator fish caught (northern squawfish, walleye, channel catfish, and smallmouth bass), weight of bait used (g), and description and value of individual operational costs, such as fuel, oil, ice, engine maintenance, and distance to launch. The observers provided bait to the fishing crews each day at the pre-arranged launching sites. At the end of each day, the agency observers collected the total catch of northern squawfish, and each fishing crew was issued a voucher for their catch. The catch was frozen and stored for market testing.

The University of Washington (UW) subcontract (Report C, this volume) supported the commercial fishery component of the test fishery by facilitating the transfer of appropriate technology to the commercial fishermen. Thus, a controlled, observed, subsidized commercial fishery, aided by the transfer of technology from previous research, was implemented. In addition to baseline funding to cover daily operating costs (fuel, engine operation and maintenance, and opportunity wages), fishermen received from BPA a bonus incentive of \$4 per fish caught. This subsidy was intended to stimulate the "reward-according-to-production" format of an unsubsidized commercial fishery. Under the subcontract to UW, all of the longlining equipment, terminal gear, and bait was provided to the three boats from June through August. UW project personnel advised and helped fishermen in outfitting their boats and organizing gear. Fishermen were instructed in all phases of fishing including times, areas, and methods of gear deployment. The UW supplied fishermen with bait and periodically monitored fishing activities to offer suggestions for improved efficiency, receive input for methods to improve efficiency, and take incidentally caught food and game fish for tests of hooking and handling mortality.

Lure Trolling Study

We collected northern squawfish by trolling various lures from 20 August through 5 October in the forebay and tailrace of Bonneville Dam (Figures 4 and

5). This was a feasibility test of an additional method to harvest northern squawfish in the proximity of dams.

A 28-foot aluminum inboard boat with two downriggers was used for trolling fishing lures. Three lures were trolled from each downrigger allowing a total of six lures to be used during each one-hour unit of effort. Lures were selected randomly from a list (Table 2) for each test. One lure was attached to the downrigger ball with 40 lb test leader. Two additional lures were attached by lines to each downrigger cable with release clamps and fished with poles. This allowed control of the depth of each lure and its distance behind the boat. The lures were changed after each hour of fishing and the lines were retrieved at least every fifteen minutes to check for fish and possible line tangles. An Impulse 2800 Plus fish finder was used to determine the approximate depth of the water and the depth of the downrigger ball was set accordingly. Sea anchors were used to reduce trolling speed when needed. Fork length (mm) and scale samples were collected for each fish.

Laboratory Procedures

Scale Analysis

Scale samples were collected from fish captured by each fishery from April through August 1990. Scales from northern squawfish and smallmouth bass were collected on the left side of the fish above the lateral line posterior to the dorsal fin. Scales from walleye were collected on the left side of the fish below the lateral line, near the point of the pectoral fin when the fin is pressed to the body. Scale samples (10-20 scales) from individual fish were placed inside a paper envelope on which species, sex, collection date, collection number, and location were recorded.

For each reservoir, samples from 10 individuals (5 male and 5 female) were randomly selected for each 25-mm length group. If the initial random sample was not comprised of equal numbers of males and females, it was supplemented to obtain 5 scale samples from each sex. Uniformly shaped, unregenerated scales from each individual sample were selected for mounting. Selected scales (4 per fish) from up to 10 individuals were impressed on acetate sheets using a Carver Press. Scale impressions were aged using methods described by Jerald (1983) and Bagenal and Tesch (1978). An "n" age designation was assigned to fish collected during the growth season following annulus formation and preceding January 1 of the next year. An "n +" designation was assigned to fish collected between January 1 and the following growth season. For subsequent age group analysis, fish aged as n + were grouped with fish aged as n + 1.

Gonad Analysis

Fecundity was estimated by a gravimetric subsample method (Simpson 1959, Wolfert 1969). Gilson's solution was drained from the ovary samples through a sieve (0.333 and 0.270 mm) that had been pre-weighed and tared on a Mettler PC 180 scale. The eggs were rinsed with water to remove any remaining preservative. We then removed excess tissue from the sample. Any eggs remaining clumped together were separated. The sieve was wiped dry with paper towels and the screen was blotted from the underside to draw off excess water.

Table 2. List of lure types used for the trolling lure fishery.

Description	Code
Luhr Jensen, Tee-Spoon, nickel, (1/3 oz.)	9501
Luhr Jensen, Tee-Spoon, brass, (1/3 oz.)	9502
Luhr Jensen, Crippled Herring, chrome, (3/4 oz.)	9503
Luhr Jensen, Crippled Herring, blue/chrome, (3/4 oz.)	9504
Luhr Jensen, Hot Shot #30 rainbow	9505
Luhr Jensen, Hot Shot #30 fire	9506
Luhr Jensen, Hot Shot #30 chrome	9507
Les Davis, Bang Tail, shrimp scale, (1/4 oz.)	9508
Les Davis, Bang Tail, chartreuse/black scale, (1/4 oz.)	9509
Luhr Jensen, Kwikfish, silver shad, #K12	9510
Luhr Jensen, Kwikfish, orange/black, #K12	9511
Luhr Jensen, Kwikfish, rainbow trout, #K12	9512
Luhr Jensen, Hi-Catch, silver/blue, (5/16 oz.)	9513
Luhr Jensen, Hi-Catch, perch, (5/16 oz.)	9514
Luhr Jensen, Hi-Catch, rainbow trout, (5/16 oz.)	9515
Luhr Jensen, Speed Trap, silver/blue, (1/4 oz.)	9516
Luhr Jensen, Speed Trap, Tennessee shad, (1/4 oz.)	9517
Salmonid smolts behind Luhr Jensen six pak set up	9518
Salmon smolts on hook - 3/0 bait hook	9520

from the eggs. The total sample was then air dried for a standard time, weighed (± 0.001 g), and recorded. Three subsamples of randomly mixed eggs were removed and weighed (± 0.001 g). A subsample containing approximately 200 eggs was estimated for the subsample amount and weights varied among samples according to egg size. Each subsample was counted and the numbers recorded. Total numbers of eggs were calculated by direct proportion for both subsample (F_s) and overall (F) fecundity estimates:

$$F_s = \frac{W_t \cdot N_i}{W_i}, \text{ and}$$

$$F = \frac{W_t \cdot \sum N_i}{\sum W_i},$$

where W_t = total gonad weight (preserved), W_i = weight of subsample, N_i = number of eggs counted in subsample, and i = 1 to 3.

Egg diameter (± 0.01 mm) was measured for each fish using a Bausch & Lomb Zoom 5 microscope with ocular micrometer. Five eggs from each of 3 subsamples per fish were measured in ocular units under a microscope, using a 1.5 zoom setting, then converted to millimeters (1 ocular unit = 0.06 mm). The mean egg diameter (D_m) for each fish was calculated as

$$D_m = \frac{\sum D_i}{15},$$

where D_i = diameter of an individual egg (mm), and i = 1 to 15.

Gonadal Somatic Index (GSI) was determined using the total weight of the fish (W_t) measured in the field prior to gonad removal, and gonad weight (W_g) measured fresh in the laboratory (± 0.1 g). GSI was calculated as:

$$GSI = \frac{W_g}{W_t}$$

Morphoedaphic Index

Total dissolved solids (TDS, mg/l) and specific conductivity (micromhos/cm) were analyzed by Laucks Testing Laboratories, Seattle, Washington. MEI is seasonal average TDS divided by mean reservoir depth (z).

Data Analysis

Predator Abundance Index

We calculated the total catch of northern squawfish during abundance index sampling. We also summarized the total catch of northern squawfish and other fish species for each gear and area sampled. As a preliminary index of northern squawfish abundance, we compared CPUE of northern squawfish among reservoirs for each gear, relative to CPUE in John Day Reservoir.

Morphoedaphic Index

We calculated the MEI for each area we conducted index sampling. We then compared MEI among areas.

Test Fisheries

We calculated the total catch of northern squawfish and effort for each test fishery. We calculated the percent of the catch in John Day Reservoir by dam angling, by the sport-reward fishery, and by the commercial longline fishery. We summarized the catch of northern squawfish for each fishery by location and over time. We also evaluated the effect of time of day on dam angling catch rates, and the effect of increasing the reward on sport-reward effort and catch. We compared the catch of northern squawfish during the lure trolling study among lures and depths. We also summarized the incidental catch for each test fishery.

Test Fisheries Evaluation

We compared total catch, CPUE, and size composition of the northern squawfish catch among test fisheries to evaluate the efficacy of the various fisheries in removing large, predacious fish from the population. Catch of fish marked during dam angling was compared among test fisheries to evaluate

exploitation rates. We also compared the incidental catch of other fish species among test fisheries to evaluate relative effects on the fish community.

We used information collected during abundance index sampling and the test fisheries to evaluate baseline information on northern squawfish population characteristics and characteristics of the entire fish community prior to implementation of removal fisheries. We used information from scale analyses to determine northern squawfish growth rates, survival rates, and year-class strengths. We used information from gonad analyses to determine northern squawfish fecundity and GSI. Incidental catch during index sampling was used to evaluate community structure.

Projected 1991 Fishery Harvest

We used data collected during 1990 to estimate the catch of northern squawfish by dam angling at Bonneville, The Dalles, John Day, McNary, Ice Harbor, Lower Monumental, Little Goose, and Lower Granite dams during each month from May through September 1991. First, we estimated the number of anglers at each dam forebay and tailrace during 1991. Effort (angling hours) was estimated by totaling the number of workdays between May 1 and September 30, 1991 (Monday through Friday, excluding holidays), and multiplying by six hours per day for each angler. Monthly catch of northern squawfish at each location in 1991 was estimated by multiplying the estimated number of angling hours by the catch per angling hour observed at that location during 1990 (Appendixes B and C). Catch per angling hour at Lower Monumental, Little Goose, and Lower Granite dams were assumed to be equal to that at Ice Harbor Dam.

We used catch and effort totals in John Day Reservoir during 1990 to estimate the catch of northern squawfish by sport-reward anglers in Bonneville, The Dalles, John Day, McNary, Ice Harbor, Lower Monumental, Little Goose, and Lower Granite reservoirs, and in the Columbia River below Bonneville Dam, during each month from May through September 1991. First, the number of anglers and the catch of northern squawfish each month in John Day Reservoir during 1990 (Appendix D) were expanded to estimate the number of anglers and catch during the expanded 1991 sport-bounty season. The 1991 sport-bounty season will be open from May 1 through September 30, seven days per week rather than May 24 through September 3, four days per week as in 1990. We then estimated the population within 60 miles (about a 1-hour drive) of the mid-point of each reservoir, and from a point in the Columbia River 60 miles below Bonneville Dam (Portland State University 1990, Washington Office of Financial Management 1990). We estimated the number of anglers in each reservoir and below Bonneville Dam by assuming that the ratio of anglers to available population for each location was equal to that for John Day Reservoir. Monthly catch of northern squawfish at each location in 1991 was estimated by multiplying the estimated number of anglers by the catch per angler observed in John Day Reservoir during 1990.

We used catch and effort totals in John Day Reservoir during 1990 to estimate the minimum and maximum catch of northern squawfish in the commercial longline fishery in Bonneville, The Dalles, and John Day reservoirs during 1991. First, the number of longline sets and catch of northern squawfish by each tribal fisher during 1990 were expanded to estimate the effort and catch

by each tribal fisher during the expanded 1991 commercial season. The 1991 season will be open from May 1 through September 30 rather than June 11 through August 19 as in 1990. We determined that a maximum of 473 tribal fishers were eligible to participate in the commercial fishery. We selected 20 as the minimum number of tribal fishers likely to participate in the fishery during 1991. We used aerial counts of tribal gillnets (ODFW, unpublished data) to estimate the percent of tribal fishers using each reservoir. To estimate the minimum and maximum number of tribal fishers using each reservoir in 1991 we multiplied the estimated total number of fishers (minimum and maximum) by the estimated percent of tribal fishers using each reservoir. To estimate the minimum and maximum catch of northern squawfish in each reservoir during 1991 we multiplied the estimated number of tribal fishers (minimum and maximum) by the estimated number of longline sets per fisher, and multiplied the resulting total number of longline sets (minimum and maximum) by the catch per set observed in John Day Reservoir during 1990 (Appendix E).

RESULTS

We captured over 20,000 northern squawfish in the lower Columbia and Snake rivers from 30 April to 30 August 1990. Catch of northern squawfish in various components of the study included 3,355 by index sampling, 11,005 by dam angling, 4,681 by the sport-reward fishery, 1,420 by the commercial longline fishery, and 228 by the lure trolling study.

Predator Abundance Index

Of 3,355 northern squawfish captured during predator index sampling, most (64%) were taken in tailrace or upper reservoir areas (Table 3). The greatest CPUE of northern squawfish occurred downstream from Bonneville Dam (over twice that of Bonneville forebay and the other tailrace areas). Of the fish collected by ODFW, 69% were collected by electrofishing, 22% were collected in bottom gillnets, and 9% were collected in surface gillnets. A preliminary index of relative abundance of northern squawfish based on electrofishing, bottom gillnet, and surface gillnet CPUE scaled to John Day Reservoir CPUE indicates that northern squawfish abundance varies among reservoirs (Figure 6). The electrofishing and gillnet data from indexing are presented by sampling method, week, and area in Appendix F.

Xorphoedaphic Index

TDS was generally constant in the lower Columbia River reservoirs (Table 4). Mean depth largely determined TDS. In Ice Harbor tailrace, however, TDS was substantially higher, indicating higher potential productivity in the lower Snake River. After other lower Snake and mid-Columbia river reservoirs are indexed in 1991 and 1992, MEI will be compared to CPUE indices of predator relative abundance.

Table 3. Catch of northern squawfish during predator abundance index sampling, 30 April to 30 August 1990. ODFW = Oregon Department of Fish and Wildlife; USFWS = U.S. Fish and Wildlife Service. USFWS used electrofishing only.

Reservoir, area	ODFW			USFWS
	Electrofishing	Gillnetting		
		Bottom	Surface	
Bonneville				
tailrace	216	70	5	399
forebay	163	46	6	277
mid-reservoir	88	28	7	89
upper-reservoir	52	22	15	105
The Dalles				
forebay	29	31	13	99
mid-reservoir	12	24	2	66
upper-reservoir	160	36	32	247
John Day				
forebay	35	10	10	51
mid-reservoir	13	14	11	13
upper-reservoir	62	14	7	234
McNary				
forebay	2	9	7	30
mid-reservoir	5	8	5	22
upper-reservoir	53	13	14	83
Ice Harbor				
tailrace	124	3	3	161

Test Fisheries

Dam angling accounted for the largest proportion (63%) of the 17,334 northern squawfish collected in the test fisheries. The sport-reward fishery took about 27% of the catch and the commercial longline fishery about 8%. A total of 9,951 northern squawfish were removed from John Day Reservoir by the test fisheries. This was approximately 12% of the estimated northern squawfish population in the reservoir (Beamesderfer and Rieman 1988). Of these fish, approximately 47% were caught in the sport reward-fishery, 39% were caught by dam anglers, and 14% were caught by commercial longliners.

Dam Angling

Dam angling catch varied among locations (Table 5). At Bonneville Dam powerhouse #1, mean CPUE in the tailrace was comparable to that in the

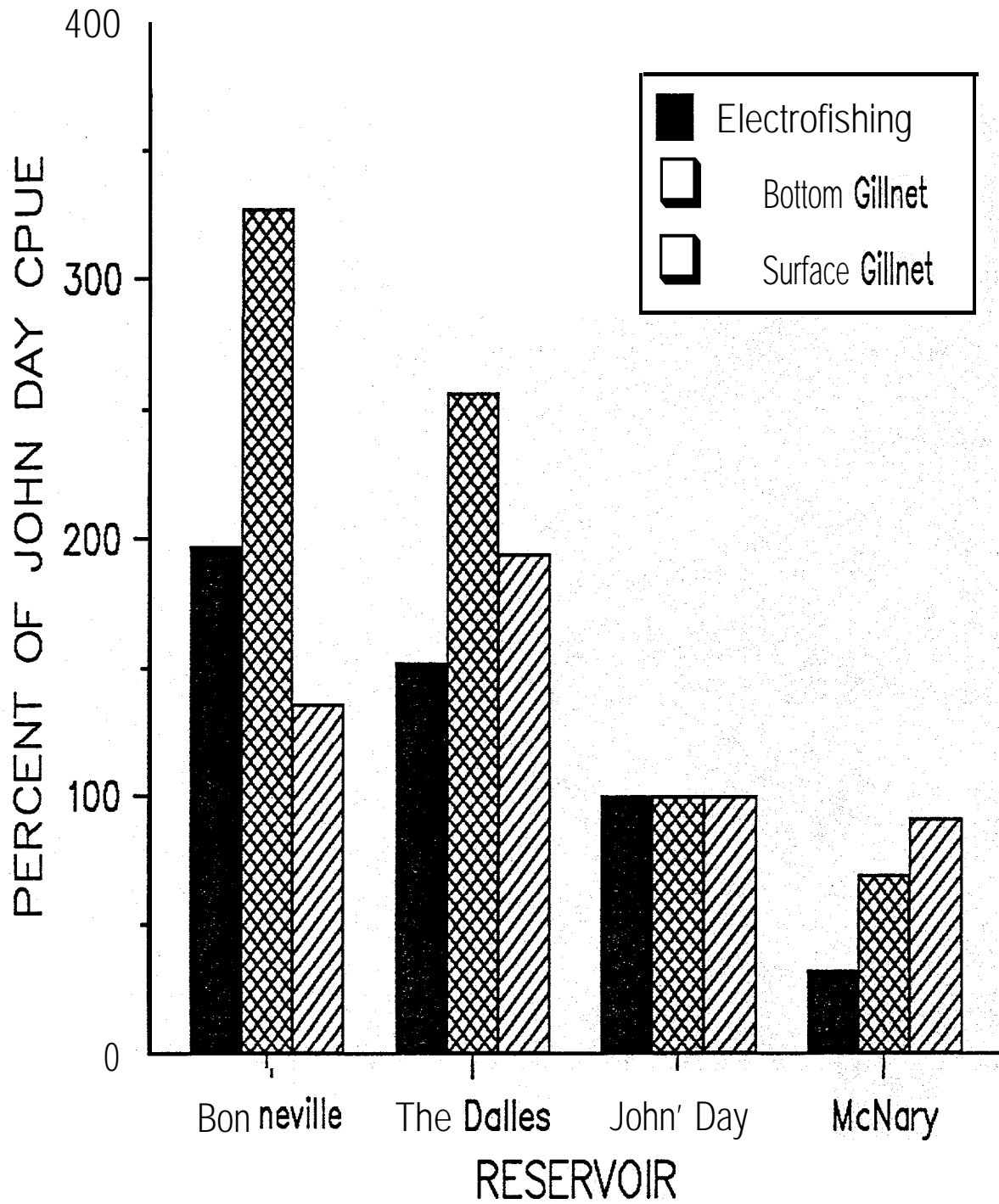


Figure 6. Index of northern squawfish abundance in Bonneville, The Dalles, John Day, and McNary reservoirs relative to that in John Day Reservoir based on electrofishing and gillnet catch per unit effort (CPUE).

Table 4. Mean seasonal total dissolved solids (TDS), specific conductivity, depth, and Morphoedaphic Index (MEI) for lower Columbia and Snake River reservoirs, based on 1990 data.

Reservoir, area	TDS (mg/l)	Specific conductivity (micromhos/cm)	Depth (z, ft)	MEI (TDS/z)
Bonneville				
tailrace	78.0	123.3	20.0	3.9
mid-reservoir	77.0	123.3	27.7	2.8
The Dalles				
mid-reservoir	77.7	120.0	31.7	2.5
John Day				
mid-reservoir	78.3	123.3	47.4	1.7
McNary				
mid-reservoir	82.0	123.3	35.4	2.3
upper-reservoir	71.7	116.7	20.0	3.6
Ice Harbor				
tailrace	100.0	133.3	48.9	2.0

forebay. At other dams, mean CPUE in the tailrace was consistently higher (3 to 12 times) than that in the forebay. CPUE at most dams was generally highest during July or August. Dam angling catch data are summarized by week and location in Appendixes B and C. We found no consistent differences between morning (0600-1430) and evening (1430-2300) CPUE at Bonneville Dam (Figure 7).

Incidental catch of non-target fish by dam angling was very low except in the tailrace at Ice Harbor Dam (Appendix G). American shad *Alosa sapidissima* and white sturgeon *Acipenser transmontanus* comprised most of the incidental catch except at Ice Harbor Dam, where channel catfish were abundant.

Sport-Reward Fishery

A total of 2,376 anglers registered in the sport-reward fishery (one or more fishermen per registrant); 781 (33%) of the registrants (representing 1,481 total anglers) returned to complete the exit interview. Of the 4,681 northern squawfish taken in the sport-reward fishery in John Day Reservoir, the majority (66.6%) were returned to LePage Park Marina. An additional 1,176 (25.1%) were returned to Umatilla Marina, and 389 (8.3%) were returned to Plymouth Marina. The sport-reward fishery data are summarized by week and access point in Appendix D.

Participation in the sport-reward fishery sharply increased following the increase in bounty from \$1.00 to \$3.00 (19 July), and then gradually declined

Table 5. Dam-angling catch of northern squawfish by dam area, 30 April to 30 August 1990. CPUE = catch per angler-hour.

Dam, area	Total Catch	Effort (angler-hrs)	Mean CPUE
Bonneville #1			
tailrace	910	414	2.20
forebay	2,463	933	2.64
Bonneville #2			
tailrace	135	350	0.39
forebay	100	897	0.11
The Dalles			
tailrace	999	701	1.43
forebay	147	330	0.45
John Day			
tailrace	1,307	811	1.61
forebay	31	244	0.13
McNary			
tailrace	3,819	656	5.82
forebay	567	638	0.89
Ice Harbor			
tailrace	527	400	1.32

(Figure 8). Participation changed from a mean of 99 anglers per week at the three locations before 19 July to a mean of 227 anglers per week after that date. Total catch was closely correlated with total participation; thus, the harvest also increased greatly after 19 July. The LePage Park Marina accounted for the majority of the increased catches during the late season (Figure 9). In the early season, CPUE peaked on 28 June and was generally highest at Umatilla Marina (about 4 fish per angler); however, participation apparently did not respond to increased CPUE since it continued to remain low over the following two weeks. After 19 July, CPUE remained relatively constant at Umatilla Marina (2-3 fish per angler) and Plymouth Marina (< 1 fish per angler); however, catch rate at LePage Park Marina increased to 7-12 fish per angler. This dramatic increase was due to the increased catches of relatively few anglers and possibly could have been due to anglers catching fish in John Day Dam Tailrace.

Commercial Longline Fishery

The commercial longline fishery harvested 1,420 northern squawfish, the least of any fishing method. Weekly catch of northern squawfish averaged about 250 from 18 June to 12 July, after which catch declined to 50-100 (Table 6). This decrease in catch can be attributed to lower fishing effort and

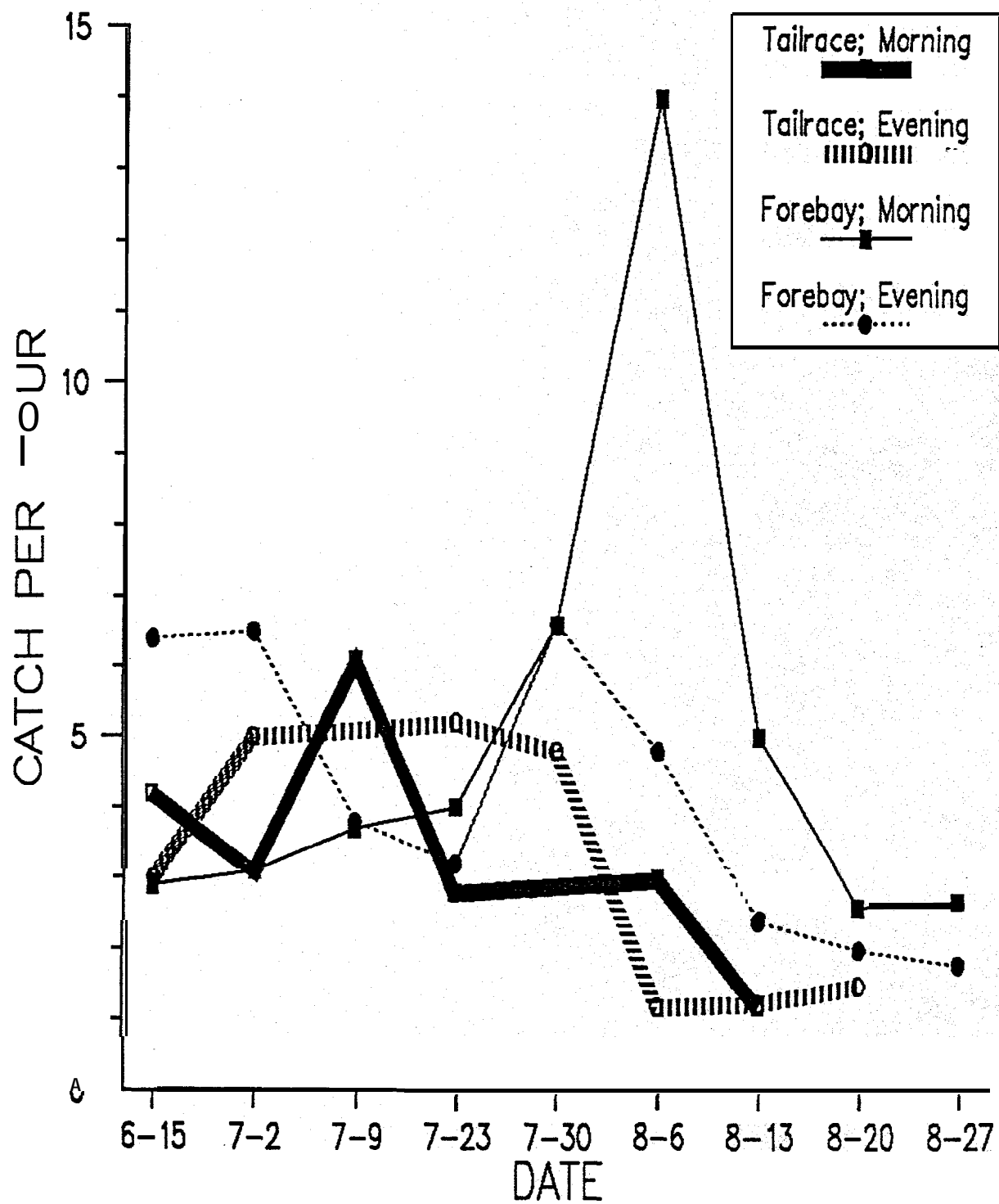


Figure 7. Catch per hour of northern squawfish during morning and evening dam angling at the forebays and tailraces of Bonneville Dam powerhouses #1 and #2, June 15 to August 27, 1990.

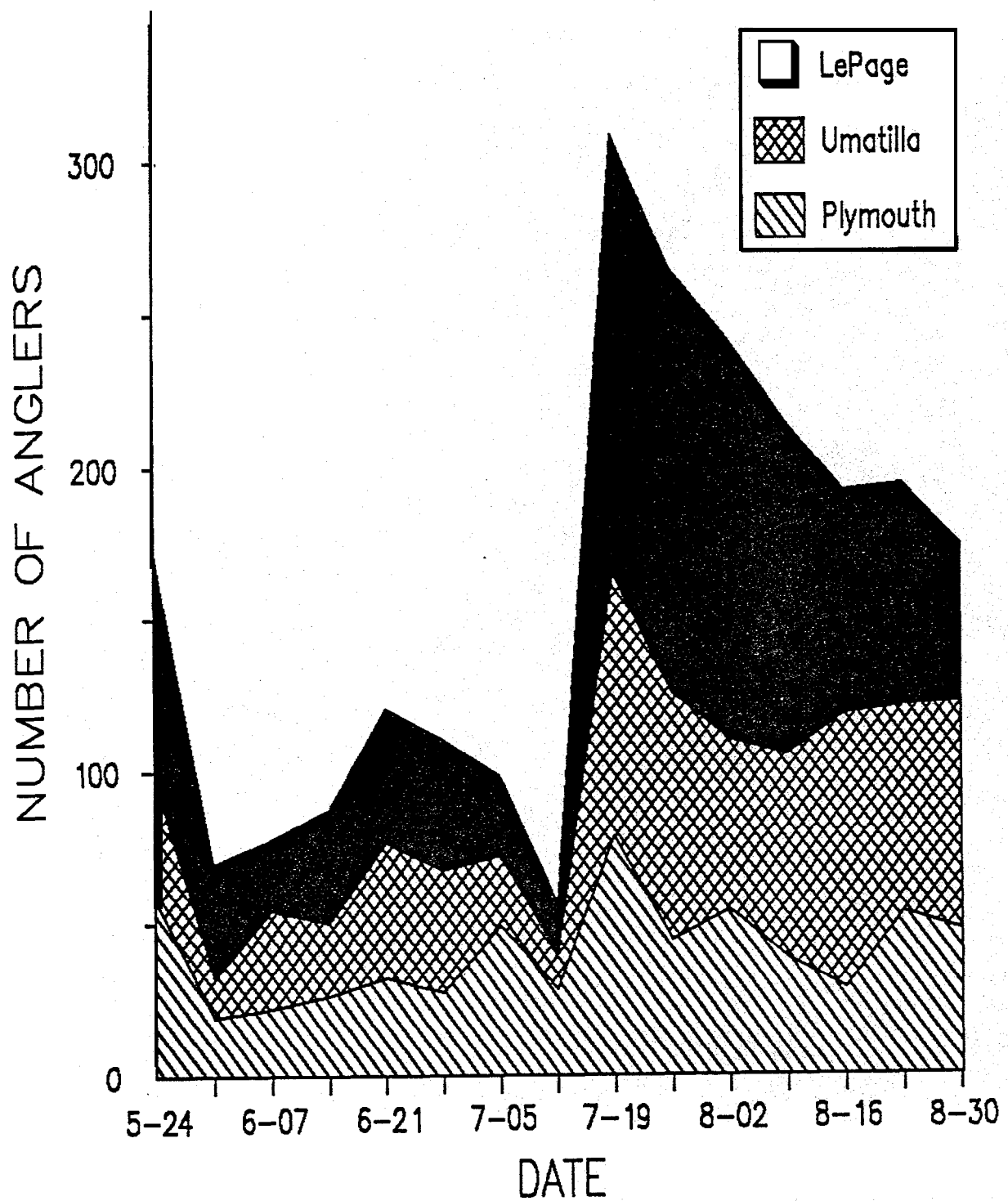


Figure 8. Participation of anglers in the sport-reward fishery at each access point in John Day Reservoir, 1990.

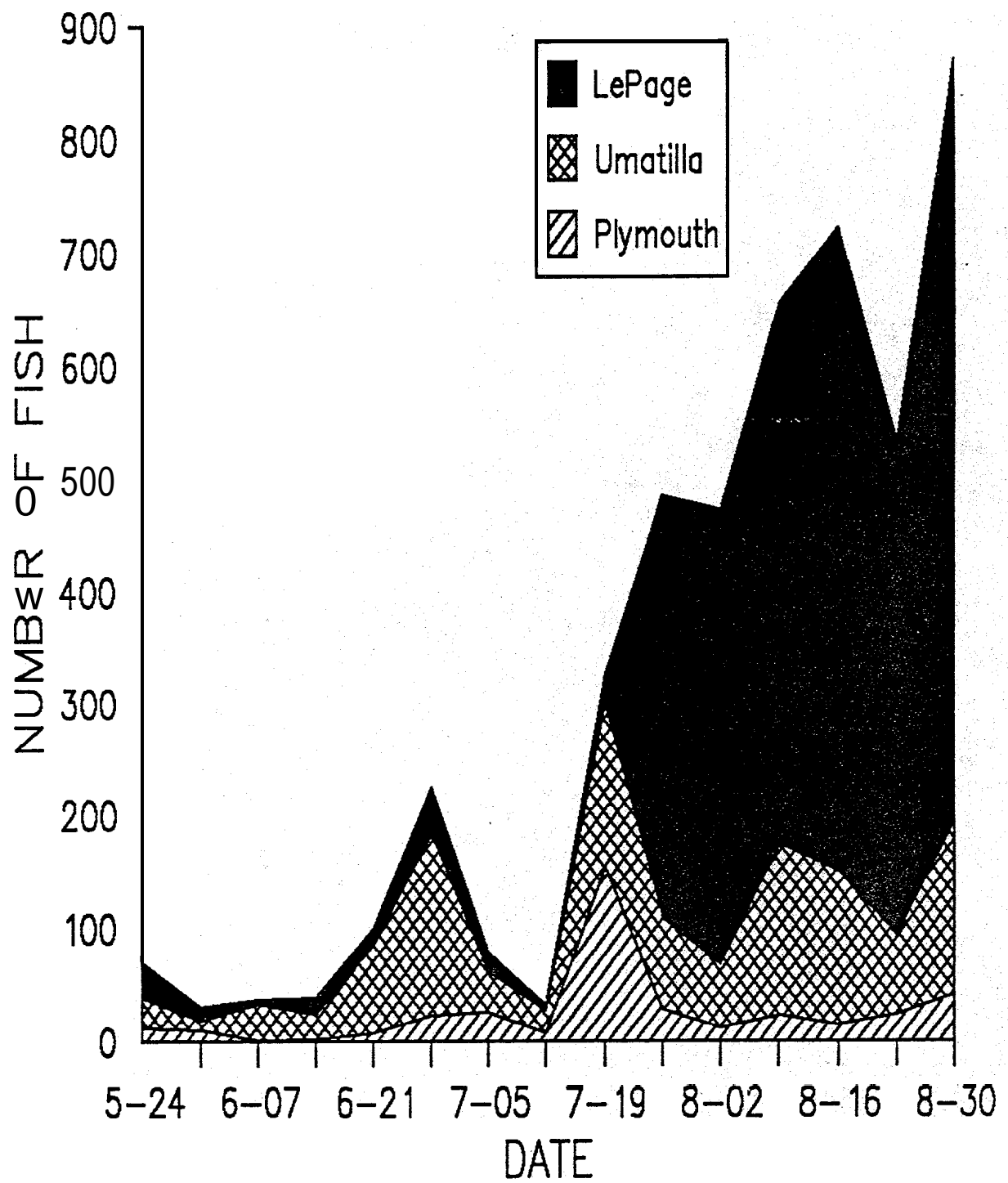


Figure 9. Catch of northern squawfish > 11 inches total length in the sport-reward fishery at each access point in John Day Reservoir, 1990.

Table 6. Catch of northern squawfish in the commercial longline fishery by week, areas and boats combined, 11 June to 9 August 1990. CPUE = catch per set.

Month, date (Monday of week)	Catch	Number of sets	CPUE
June			
11	151	99	1.53
18	270	105	2.57
25	232	90	2.58
July			
2	266	128	2.08
9	235	96	2.45
16	46	46	1.00
23	39	36	1.08
30	103	70	1.47
August			
6	78	42	1.86

lower CPUE. Effort decreased from about 100 sets per week in the early period to about 50 per week after 16 July. Commercial longline fishery data are summarized by week and location in Appendix E.

Variation also occurred in catch rates and harvest among areas and fishermen (Table 7). CPUE was higher at the upper reservoir stations (Umatilla and Irrigon marinas) than the lower reservoir station at Arlington Marina. The Hoptowit boat accounted for 48% of the total catch, followed by Blevins (33%) and Williams (19%).

Incidental catch of non-target food or game fish was relatively low in the longline fishery (Appendix G). The incidental catch consisted of one walleye, eight smallmouth bass, 182 channel catfish, and 269 white sturgeon. White sturgeon were primarily taken in the upper reservoir (61% from Umatilla, 36% from Irrigon, and 3% from Arlington). Similarly, 87% of the channel catfish catch was taken in the Irrigon and Umatilla areas.

Lure Trolling Study

A total of 228 northern squawfish were caught by trolling lures near Bonneville Dam. The majority (217) were caught in the tailrace (Table 8). We caught approximately one northern squawfish per hour in the tailrace, whereas mean catch per hour in the forebay was less than 0.1. The majority of fish caught in the tailrace were caught near the juvenile salmonid bypasses of Powerhouses #1 and #2. These areas contained higher concentrations of small fish and therefore attracted higher numbers of actively feeding northern squawfish. Our catches were highest when the lures were positioned on the edge of the turbulent zone caused by the juvenile salmonid bypass. All fish

Table 7. Catch of northern squawfish in the Commercial long-line fishery by area and boat, 11 June to 9 August 1990.
CPUE = catch per set.

Area, fisherman	Catch	Number of sets	CPUE
Umatilla			
Blevins	146	89	1.64
Hoptowit	332	108	3.07
Williams	128	69	1.86
Irrigon			
Blevins	178	85	2.09
Hoptowit	200	63	3.17
Williams	118	73	1.61
Arlington			
Blevins	158	90	1.76
Hoptowit	150	109	1.38
Williams	10	26	0.38

Table 8. Catch of northern squawfish in the troll fishery in Bonneville Dam tailrace and forebay, August-October 1990.

Location, date	Catch (c)	Effort (hr)	CPUE (c/hr)
Tailrace			
08/20 to 08/24/90	--	--	--
08/27 to 08/31/90	--	--	--
09/03 to 09/07/90	--	--	--
09/10 to 09/14/90	--	--	--
09/17 to 09/21/90	68	63.50	1.07
09/24 to 09/28/90	34	48.75	0.70
10/01 to 10/05/90	19	35.40	0.54
10/08 to 10/12/90	96	73.13	1.31
Forebay			
08/20 to 08/24/90	7	43.60	0.16
08/27 to 08/31/90	2	34.00	0.06
09/03 to 09/07/90	1	36.85	0.03
09/10 to 09/14/90	1	42.00	0.02
09/17 to 09/21/90	--	--	--
09/24 to 09/28/90	0	2.70	0.00
10/01 to 10/05/90	0	34.60	0.00
10/08 to 10/12/90	--	--	--

caught trolling were northern squawfish with the exception of one sculpin; thus the incidental catch of lure trolling was the least of any fishing method.

Mean CPUE for lures ranged from 0.05 to 1.22 (Table 9). The four lures with the highest catch rates (#9517 Luhr Jensen, Speed Trap, Tennessee Shad; #9512 Luhr Jensen, Kwikfish, Rainbow Trout; #9510 Luhr Jensen, Kwikfish, Silver Shad; #9515 Luhr Jensen, Hi Catch Rainbow Trout) accounted for 50% of the total catch while representing only about 26% of the total effort. Each of these lures simulated the movement of a small fish and have either rainbow trout or silver shad coloration.

Significant numbers of northern squawfish were caught at all depth ranges except > 30 ft (Table 10). Catch rate was highest at depths of 0-9 feet; however, the juvenile salmonid bypass outfall in powerhouse #1 tailrace is located in a shallow area and high catches there may have affected the apparent relation between CPUE and depth. In general, the variation in CPUE was less between depth ranges than it was between areas or lure types.

Projected 1991 Fishery Harvest

Dam Angling

Dam angling during 1991 may remove over 50,000 northern squawfish (Table 11). Approximately one-third of the catch would occur at McNary Dam. We project that CPUE will generally be highest in July, although at some dams CPUE may be highest in August and September.

Sport-Reward Fishery

We estimate that over 170,000 northern squawfish could be removed by sport-bounty anglers during 1991 (Table 12). More than 60% of the catch would occur in Bonneville Reservoir and in the Columbia River below Bonneville Dam. These locations are most easily accessed by the relatively large number of people living near Portland, Oregon and Vancouver, Washington. We project that most northern squawfish will be caught during August and September.

Commercial Longline Fishery

We estimate that about 20,000 northern squawfish would be harvested if 20 commercial long-line boats were fished in Bonneville, The Dalles, and John Day reservoirs (Table 13). If all the Indian fishermen that were contacted concerning the northern squawfish fishery in 1990 (473) actually fished for northern squawfish in 1991, a maximum of over 480,000 fish could be removed. Based on past gill net effort distribution, we project that catch would be less in The Dalles Reservoir than in Bonneville or John Day reservoirs.

Table 9. Catch of northern squawfish by lure type in the troll fishery in Bonneville Dam tailrace and forebay, August-October 1990.

Lure Type	Total Catch (c)	Total Effort (hr)	Mean CPUE (c/hr)
9501	3	29.72	0.10
9502	1	21.57	0.05
9503	8	27.27	0.29
9504	10	20.13	0.50
9505	4	16.00	0.25
9506	1	16.63	0.06
9507	17	26.02	0.65
9508	6	15.73	0.38
9509	12	29.90	0.40
9510	17	15.92	1.07
9511	5	12.45	0.40
9512	39	32.95	1.18
9513	13	22.20	0.59
9514	8	19.28	0.41
9515	28	33.98	0.82
9516	19	23.22	0.82
9517	30	24.65	1.22
9518	3	8.97	0.33
9520	4	18.45	0.22

DISCUSSION

Predator Abundance Index

Differences in mean CPUE of northern squawfish among reservoirs indicates that abundance of northern squawfish may consistently decrease from lower river to upper river reservoirs. However, CPUE may not be the best indicator of northern squawfish abundance. Vigg and Burley (1991) showed that differences in the relative frequency of zero catches and the natural logarithm of non-zero catches may be better indices of differences in abundance. We will compare differences in these indices among reservoirs and among areas within reservoirs to compare differences in relative abundance. We will also work with the USFWS to combine our abundance index with their consumption index and produce a predation index.

Mean CPUE of northern squawfish by ODFW and USFWS electrofishing crews showed consistent differences among reservoirs. Mean CPUE in Bonneville was nearly equal for ODFW and USFWS crews, whereas CPUE by USFWS in other reservoirs exceeded CPUE by ODFW. This may be attributed to nonrandom sampling effort by USFWS. Their effort was concentrated in areas with the greatest catch. Additionally, USFWS effort was greater during peak juvenile salmonid out-migration (and presumably peak northern squawfish density) to maximize sample size for stomach content analysis. In contrast, ODFW effort

Table 10. Catch of northern squawfish by depth in the troll fishery in Bonneville Dam tailrace and forebay, August - October 1990.

Location, depth (ft)	Catch (c)	Effort (hr)	CPUE (c/hr)
Tailrace			
0-9	70	55.13	1.27
10-19	81	96.77	0.84
20-29	66	68.88	0.96
>30	0	0.00	0.00
Forebay			
0-9	5	38.75	0.13
10-19	3	83.77	0.04
20-29	2	53.97	0.04
>30	1	17.27	0.06

was stratified over a broader time period to yield a more representative estimate of predator density in reservoirs.

Index sampling will continue during 1991. We will electrofish and use gillnets in Ice Harbor, Lower Monumental, Little Goose, and Lower Granite reservoirs to collect initial index data. Sampling will also continue in John Day Reservoir as a control by which to compare data from the other reservoirs.

Test Fisheries

Dam Angling

Including dam angling in the test fishery had two purposes: (1) to enable realistic comparison of the effectiveness of dam angling compared to commercial and recreational fisheries, and (2) to implement northern squawfish removal as soon as possible at high priority areas, while concurrently providing predator abundance index information. Results indicated that dam angling can remove a substantial number of northern squawfish, particularly from tailraces. Based on previous estimates of northern squawfish abundance (Beamesderfer and Rieman 1988), our limited dam angling in 1990 removed over four percent of the northern squawfish present in John Day Reservoir. The increased dam-angling effort expected in 1991 should result in a much higher percentage of northern squawfish removal.

Sport-Reward Fishery

Removing substantial numbers of northern squawfish by offering a reward to sport anglers also appears feasible. Over five percent of the northern squawfish estimated to reside in John Day Reservoir (Beamesderfer and Rieman 1988) were removed by sport anglers during 1990. Most of these fish were

Table 11. Projected **removals** of northern squawfish by dam **angling** during 1991.
C = projected catch. CPUE = projected catch per angler hour. Projected angler
hours = 132 during Flay, July, and August; 120 during June and September **at** each dam

Dam ^a	Month									
	May		June		July		August		September	
	C	CPUE	C	CPUE	C	CPUE	C	CPUE	C	CPUE
Bonneville										
Tailrace	444	0.84	1,046	2.18	2,381	4.51	750	1.42	682	1.42
Forebay	760	1.44	1,382	2.88	2,629	4.98	1,104	2.09	1,103	2.09
The Dalles	327	0.62	259	0.54	766	1.45	1,663	3.15	1,512	3.15
John Day	612	1.16	350	0.73	1,695	3.12	1,177	2.23	1,070	2.23
McNary	1,890	3.58	3,994	a.32	7,535	14.27	1,948	3.69	1,771	3.69
Ice Harbor	158	0.30	240	0.50	919	1.74	1,024	1.94	931	1.94
Louer Monumental	158	0.30	240	0.50	919	1.74	1,024	1.94	931	1.94
Little Goose	158	0.30	240	0.50	919	1.74	1,024	1.94	931	1.94
Lower Granite	158	0.30	240	0.50	919	1.74	1,024	1.94	931	1.94

^a Estimates for dams other than Bonneville are for **tailrace** only.

caught after the reward was increased from \$1.00 to \$3.00. Increased publicity about the sport-reward fishery, and the longer season (1 May through 30 September) expected during 1991 should result in increased numbers of northern squawfish being removed.

Commercial Longline Fishery

The commercial longline fishery removed less than two percent of the estimated numbers of northern squawfish in John Day Reservoir; however, the effectiveness of removing northern squawfish by commercial longlining can not be adequately evaluated based on 1990 results. Constraints on getting started resulted in a later start date than other fisheries. Additionally, constraints on times and areas fished, relatively low catch rates of northern squawfish (about 2 per long-line set), decreased catch rates and therefore decreased monetary incentive in the second half of the season, and lack of interest in extending the season past the start of the salmon fishery above Bonneville Dam all affected the catch. An increase in the number of longliners participating and a longer sampling season during 1991 should

Table 12. Projected removal of northern squawfish by the sport-reward fishery during the 1991 field season. N = projected number of anglers. C = projected catch. Dams are BB = below Bonneville, BV = Bonneville, TD = The Dalles, JD = John Day, MN = McNary, IH = Ice Harbor, LM = Lower Monumental, LG = Little Goose, and GR = Lower Granite.

Dam	Potential Population	Month									
		May		June		July		August		September	
		N	C	N	C	N	C	N	C	N	C
BB	1,827,501	12,713	2,644	9,112	4,155	13,450	8,877	15,649	22,926	11,811	28,701
BV	1,036,532	7,211	1,500	5,168	2,356	7,628	5,035	8,876	13,003	6,699	16,279
TD	206,861	1,439	299	1,031	470	1,522	1,005	1,771	2,595	1,337	3,249
JD	332,358	2,312	481	1,657	756	2,446	1,615	2,846	4,170	2,148	5,220
MN	288,502	2,006	417	1,438	656	2,123	1,401	2,470	3,619	1,865	4,531
IH	295,312	2,054	427	1,472	671	2,173	1,434	2,529	3,705	1,909	4,638
LM	285,050	1,983	412	1,421	648	2,101	1,387	2,441	3,576	1,842	4,477
LG	222,356	1,547	322	1,109	506	1,636	1,080	1,904	2,789	1,437	3,492
CR	160,083	1,114	232	798	364	1,178	778	1,371	2,008	1,035	2,514

allow the effectiveness of the commercial fishery to be compared to that of the other test fisheries.

Lure Trolling Study

Catch of northern squawfish by trolling lures can be increased dramatically by concentrating effort in areas where northern squawfish are actively feeding on juvenile salmonids or other small fish near juvenile salmonid bypasses. During 1991 we will limit the lures to those that have proven effective, and we will begin sampling earlier in the year to increase our catch of northern squawfish. We will also draw upon knowledge of trolling techniques gained during 1990 sampling. For example, by the end of the 1990 season we learned how to best position the boat in high catch areas and how to effectively bring in large numbers of fish in a short period of time.

Table 13. Projected removals of northern squawfish by the commercial longline fishery during the 1991 field season. Maximum and minimum number of participating boats estimated at 473 and 20, respectively.

Dam	% Effort	Minimum			Maximum		
		Fishermen	Sets	Catch	Fishermen	Sets	Catch
Bonneville	41	a	4, 157	a, 272	194	100, 815	191, 549
The Dalles	24	5	2, 598	5, 171	114	59, 242	117, 892
John Day	35	7	3, 638	7, 239	166	86, 265	171, 667

Test Fisheries Evaluation

The predator control program is one of the salmonid enhancement measures that has great potential to increase the survival of juvenile salmonids in the Columbia River system, especially if the hypothesis is true that a 10-20% sustained harvest of northern squawfish can reduce predation mortality by 50%. The potential for Endangered Species Act listing of certain depleted stocks of Snake River chinook and sockeye salmon has increased the momentum to take immediate actions that will increase the survival of juvenile salmonids. If in the spring of 1991, the National Marine Fisheries Service recommends that any of the stocks be proposed for listing as threatened or endangered, even more impetus will exist to maximize the predator control program.

It will be important to determine if northern squawfish populations somehow compensate to reduce the effects of the test fisheries. Compensation is a density-dependent process which has been defined as the ability of a fish population to offset, in whole or part, reduction in numbers caused by the impacts from natural or artificial stresses, including fishing (Saila et al. 1987). Compensatory mechanisms include growth, reproduction, growth and predation, density and predation, cannibalism, competition for spawning sites, agonistic behavior, starvation, parasitism and disease, and emigration (Saila et al. 1987). Reproductive mechanisms include individual and population fecundity, sexual maturity, sex-ratio, size composition of spawners, egg size, larval size, life history strategy, spawning migrations, and spawning behavior.

To evaluate the effects of test fisheries on northern squawfish populations in the various reservoirs, northern squawfish population structure, fecundity, GSI, age and growth, and survival before and after sustained fisheries will be compared. Community structure (relative abundance of other fish species) before and after sustained fisheries will also be compared. Pre-treatment baseline data collection and index sampling was done concurrently during 1990. Summary and analysis of baseline data will be conducted after we complete scale and gonad analyses. Final conclusions as to

the efficacy of sustained northern squawfish fisheries in achieving the goal of salmonid enhancement are at least five years off.

We will also evaluate the efficiency of each test fishery. Size composition of the northern squawfish catch will be compared among fisheries to compare catch rates of predator-sized fish. Species composition will also be compared among fisheries to evaluate incidental catch and effects on community structure.

Fishery exploitation rates and abundance of northern squawfish populations will be estimated, and assumptions necessary for abundance estimates tested using mark and recapture techniques. During 1991 we will tag northern squawfish collected during dam angling and index sampling. Tagged fish may subsequently be recaptured during the three removal fisheries and index sampling. Exploitation rate will be estimated for each fishery to determine if the fisheries are achieving desired harvest levels. Northern squawfish population estimates will be made to enable an independent estimate of exploitation using abundance estimates and known numbers removed. Population abundance estimates will also be used (if assumptions are met) to evaluate annual population changes (in conjunction with CPUE trends), and as input to simulation modeling.

Projected 1991 Fishery Harvest

Although many of the projected 1991 catches of northern squawfish appear reasonable, the validity of some of the estimates are questionable. Sport-bounty catches for September are based on an extremely high catch rate observed during a very limited period (three days) during September 1990, and are probably over-estimated. Our method for estimating sport-bounty catch resulted in catches for a location being directly proportional to the population near that location; therefore, projected catches in Bonneville Reservoir and the Columbia River below Bonneville Dam may be over estimated due to the proximity of these locations to Portland, Oregon. All sport-bounty catches may be slightly over estimated because most potential anglers live within 60 miles of more than one reservoir (and were therefore included in the potential population of more than one reservoir) but will fish only in one reservoir.

Estimated removals of northern squawfish by dam angling appear reasonable. However, estimates at Snake River dams are based on results from Ice Harbor Dam only. Although probably reasonably accurate, projected catches at Lower Monumental, Little Goose, and Lower Granite dams may be over or under estimated.

Maximum removal of northern squawfish by the commercial long-line fishery in Bonneville, The Dalles, and John Day reservoirs during 1991 is over estimated. Estimates approach or exceed the number of northern squawfish likely to reside in each reservoir. In addition, if every eligible tribal fisher participated, catch per long-line set would most likely decline to levels below that observed in John Day Reservoir during 1990.

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APPENDIX A. Predator abundance indexing and test fisheries sampling locations and sampling location codes, 1990.

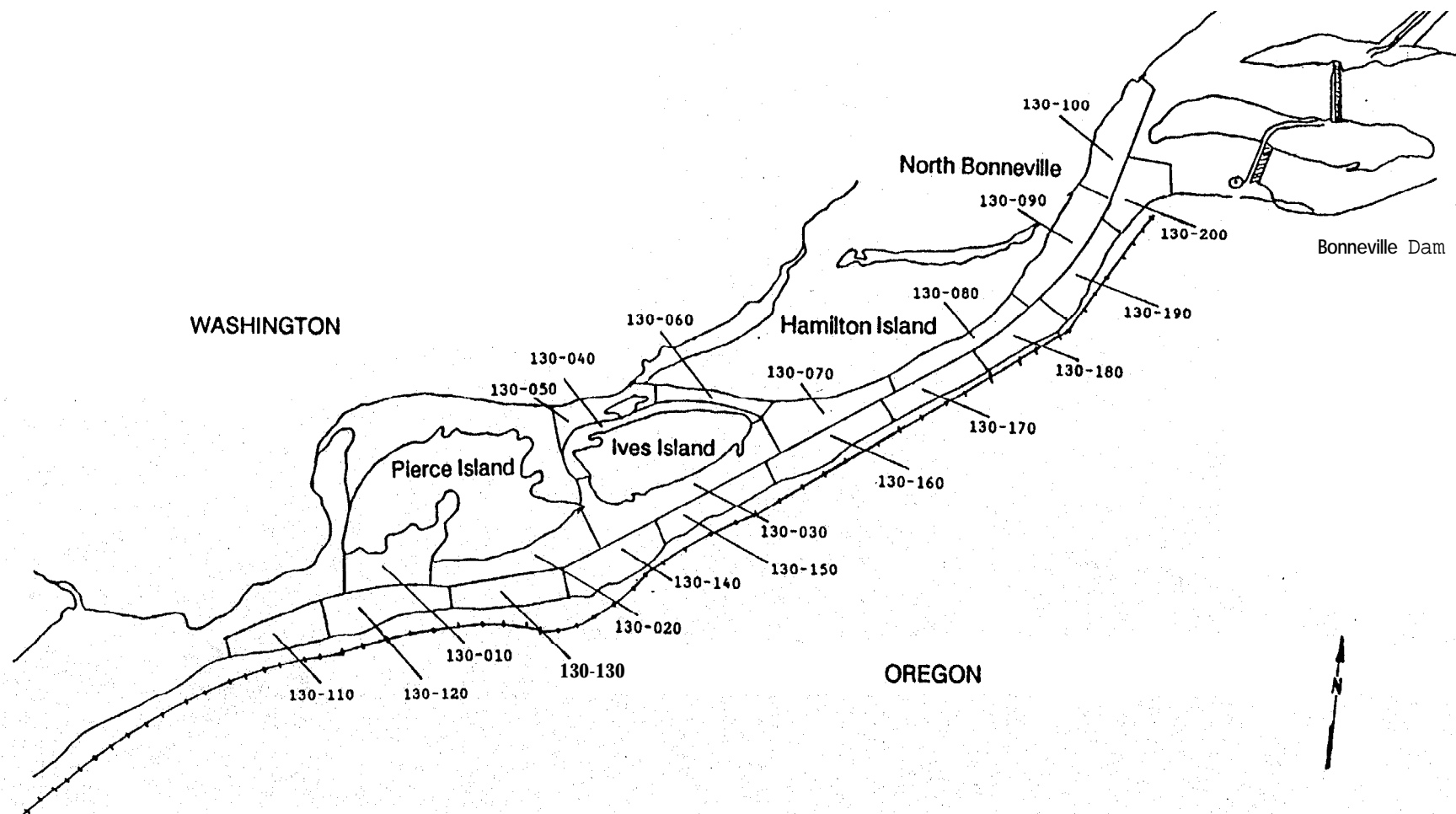


Figure A-1. Predator abundance indexing sampling locations and sampling location codes, Bonneville Dam tailrace, 1990.

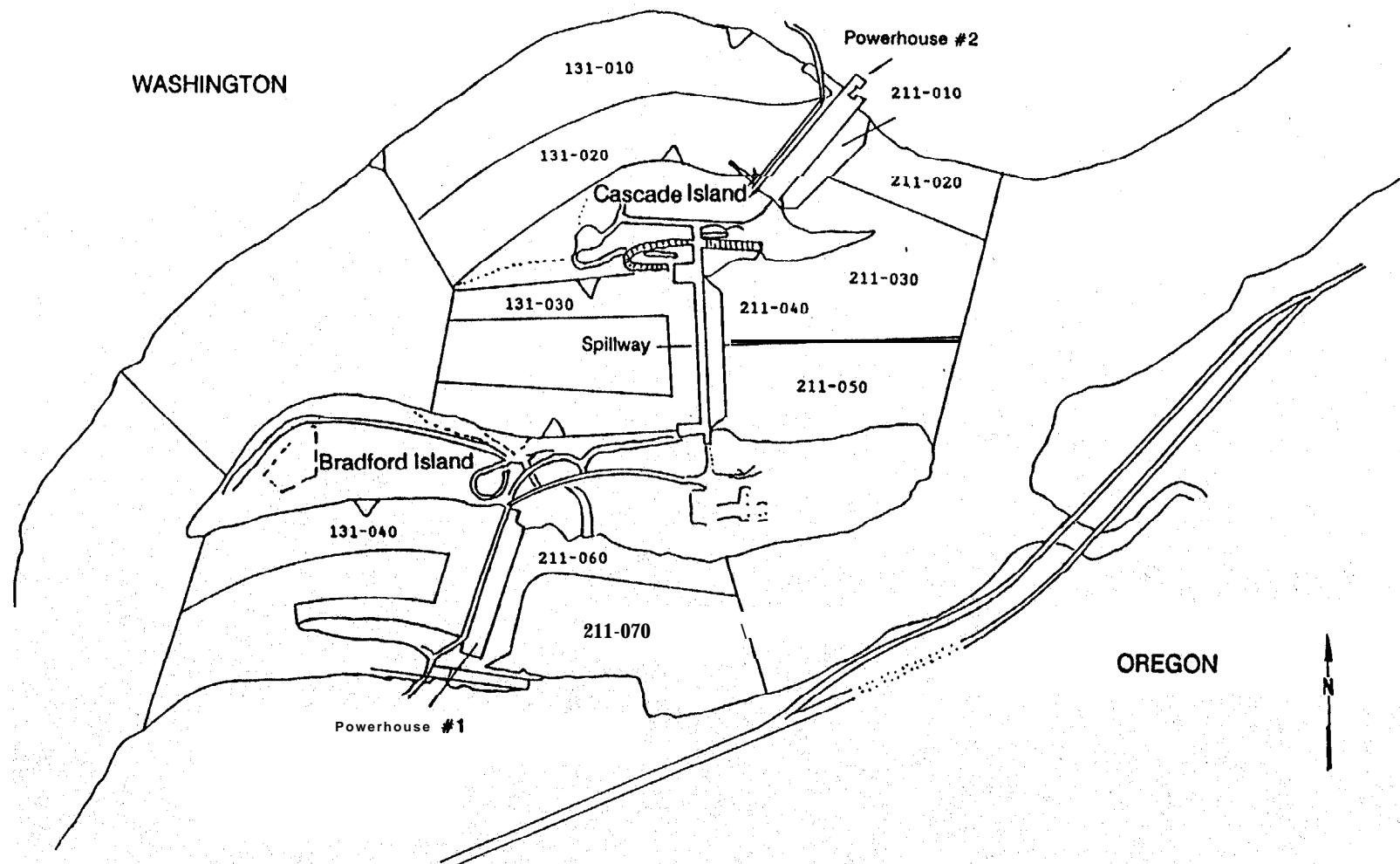


Figure A-2. Predator abundance indexing sampling locations and sampling location codes, Bonneville Dam tailrace and forebay_{boat} restricted zones, 1990.

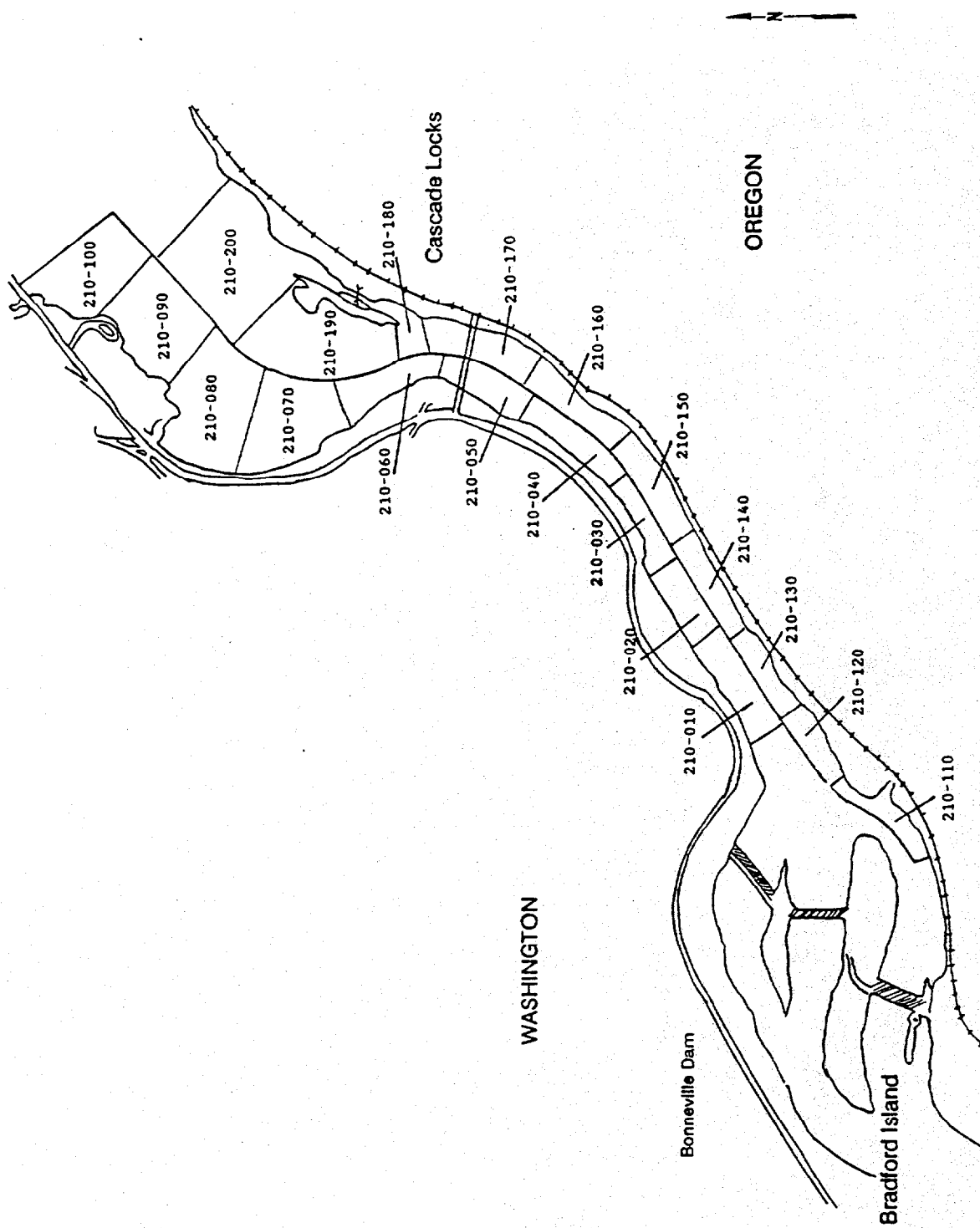


Figure A-3. Predator abundance indexing sampling locations and sampling location codes, Bonneville Reservoir forebay, 1990.

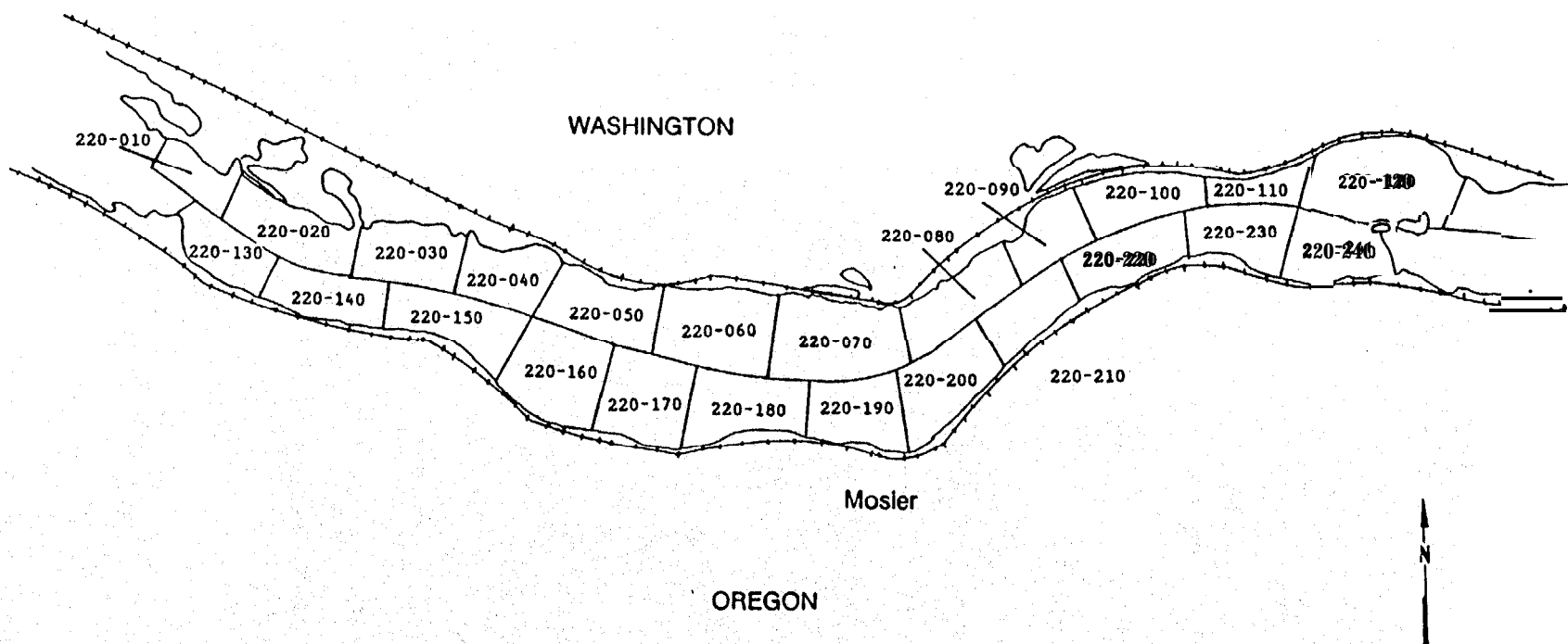


Figure A-4. Predator abundance indexing sampling locations and sampling location codes, mid-Bonneville Reservoir, 1990.

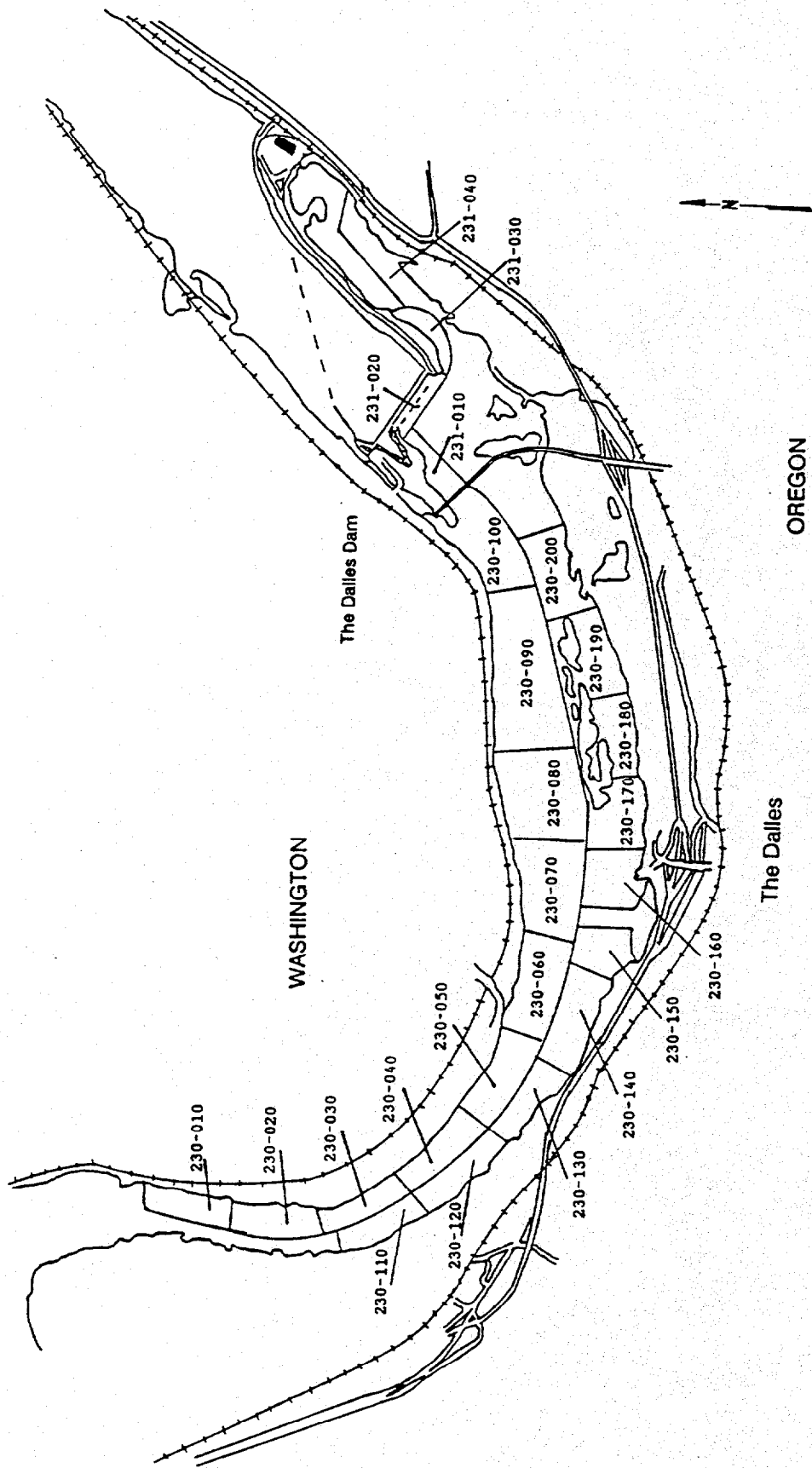


Figure A-5. Predator abundance indexing sampling locations and sampling location codes, The Dalles Dam tailrace and boat restricted zone, 1990.

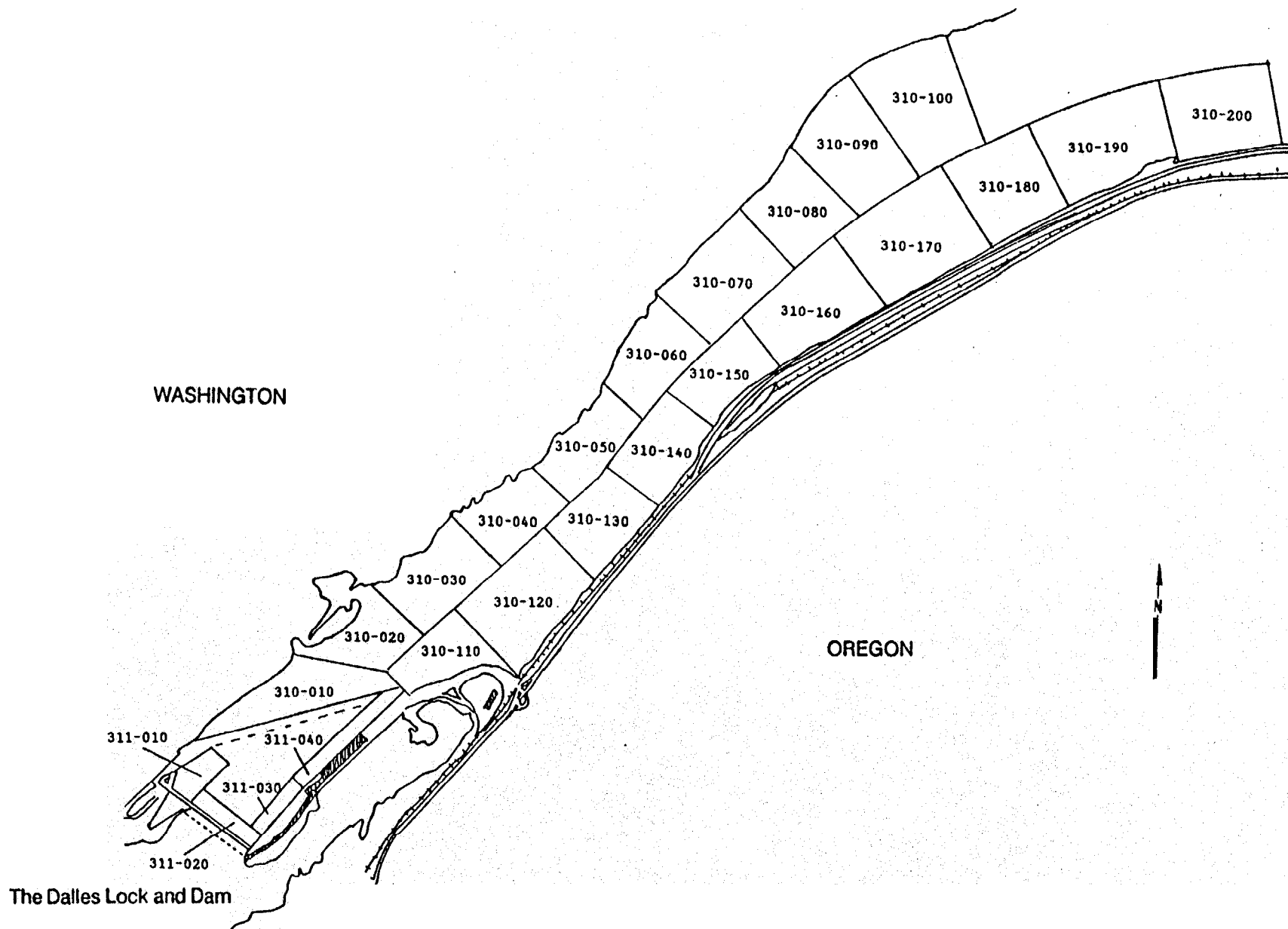


Figure A-6. Predator abundance indexing sampling locations and sampling location codes, The Dalles Dam forebay and boat restricted zone, 1990.

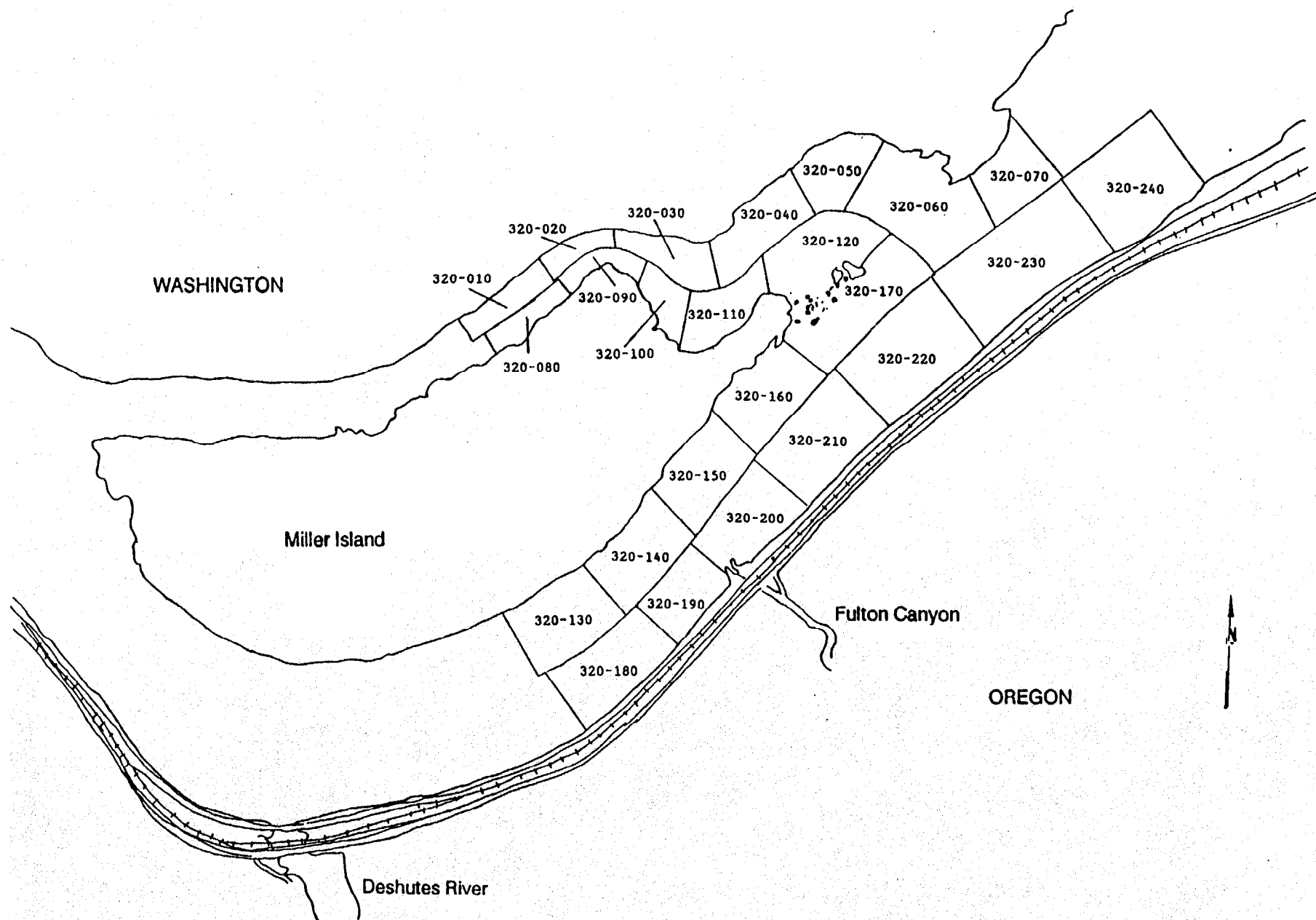


Figure A-1. Predator abundance indexing sampling locations and sampling location **codes**, mid-The Dalles Reservoir, 1990.

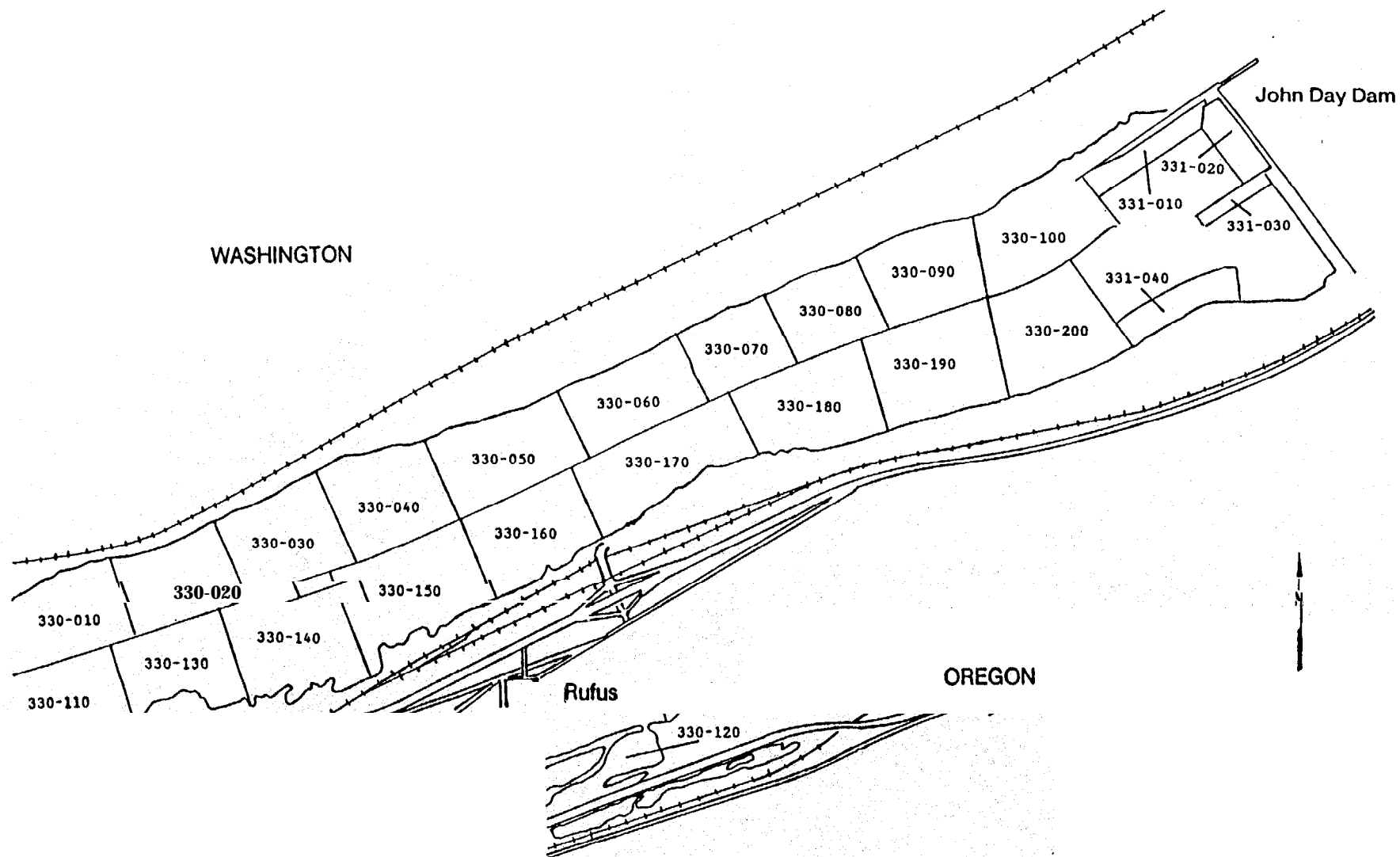


Figure A-8. Predator abundance indexing sampling locations and sampling location codes, John Day Dam tailrace and boat restricted zone, 1990.

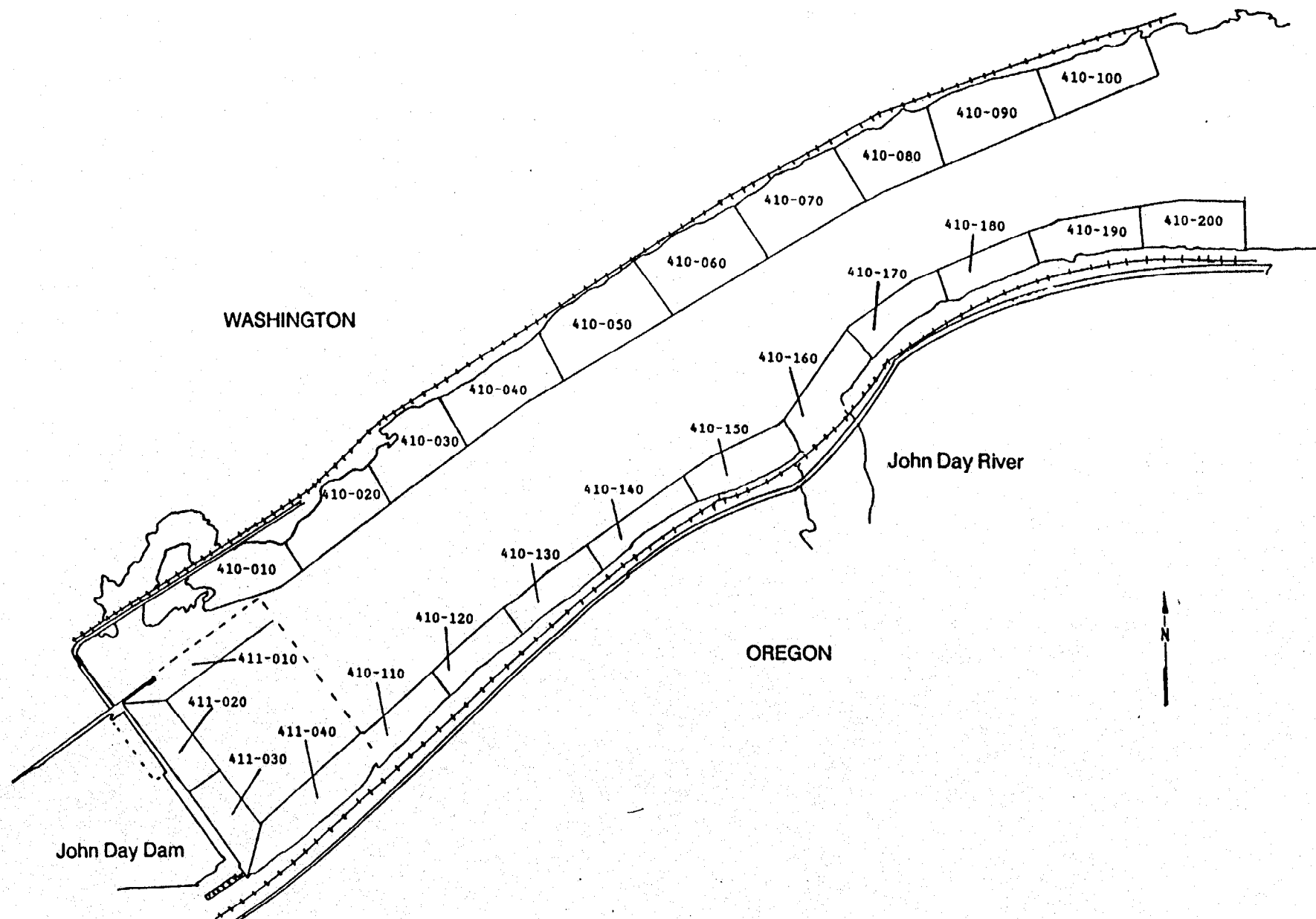


Figure A-9. Predator abundance indexing sampling locations and sampling location codes, John Day Dam forebay and boat restricted zone, 1990.

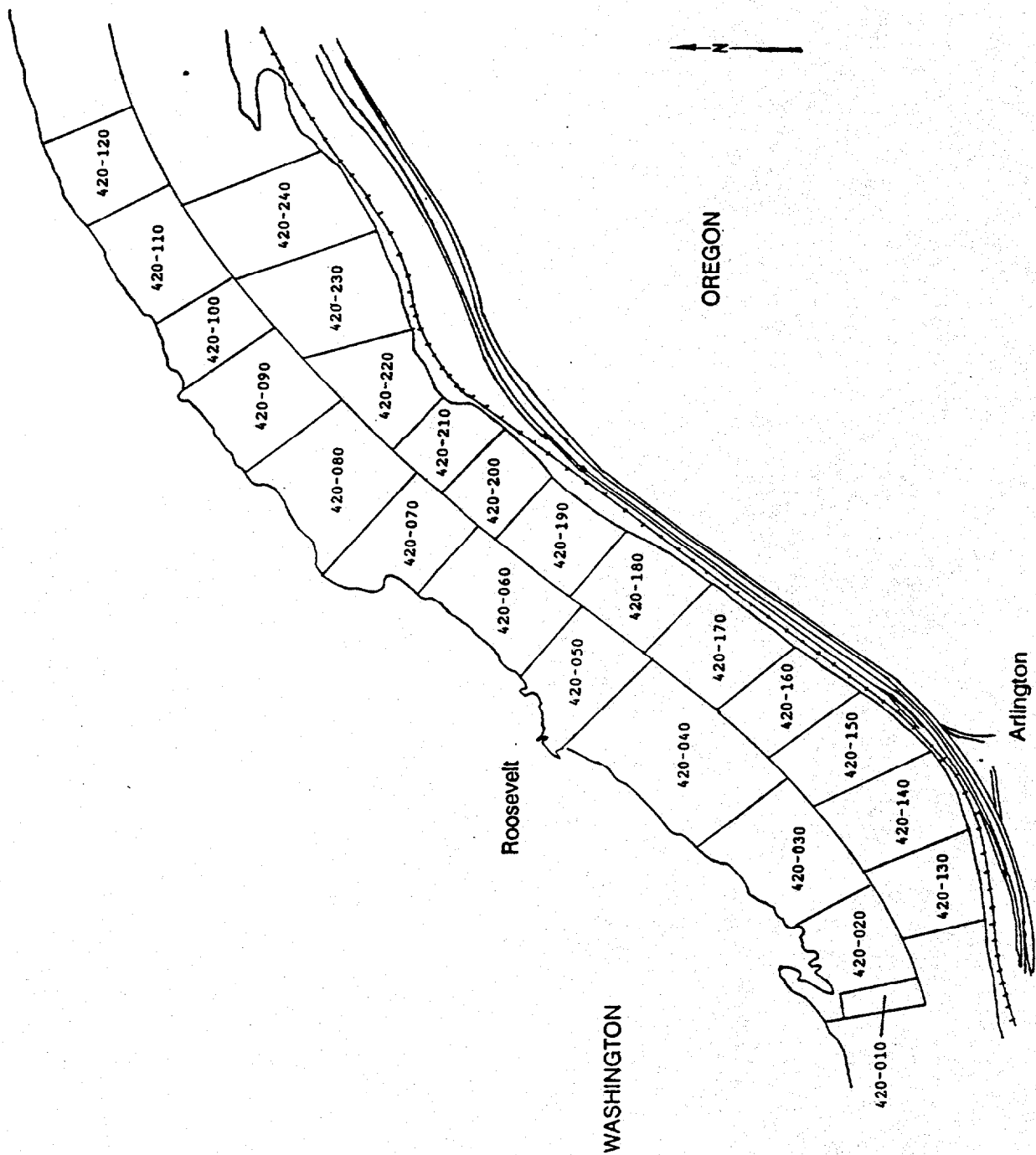


Figure A-10. Predator abundance indexing sampling locations and sampling location codes, mid-John Day Reservoir, 1990.

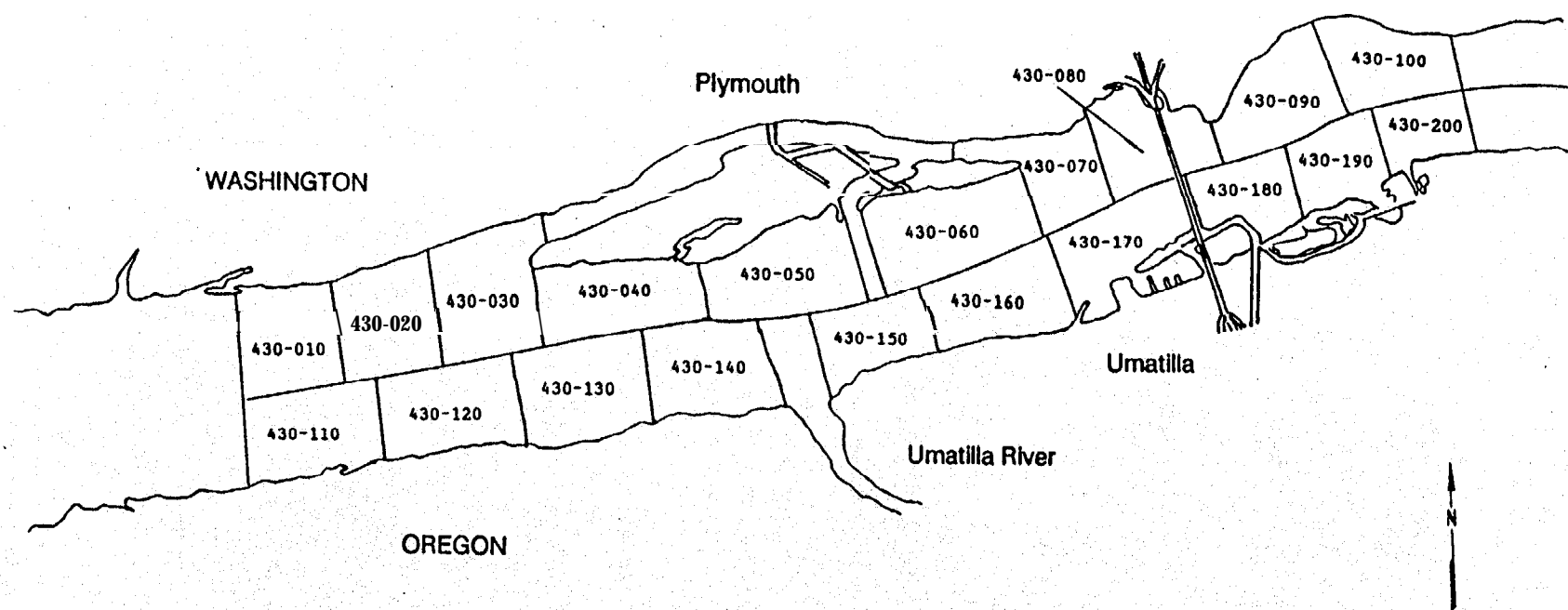


Figure A-11. Predator abundance indexing sampling locations and sampling location codes, McNary Dam tailrace, 1990.

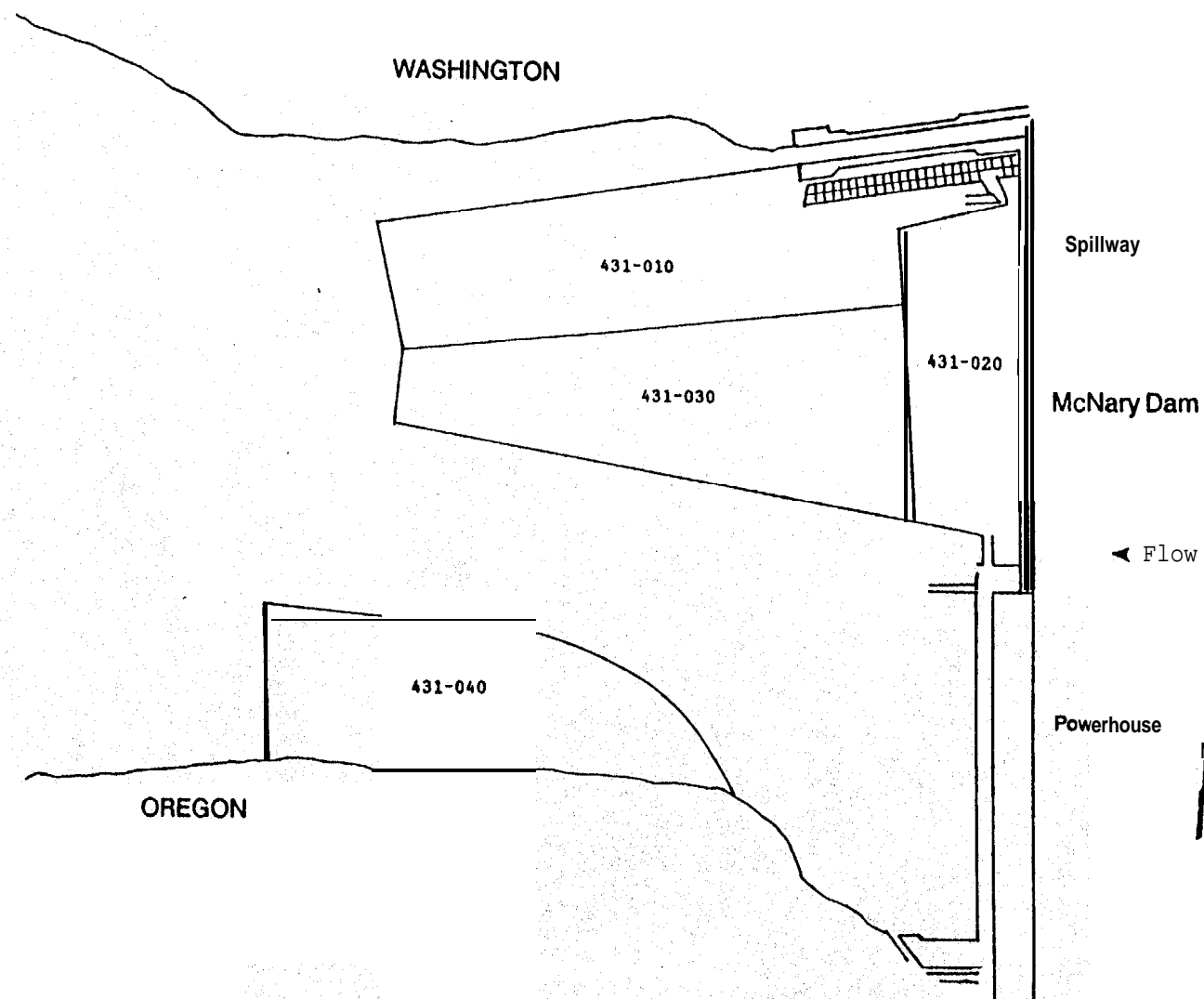


Figure A-12. Predator abundance indexing sampling locations and sampling location codes, McNary Dam tailrace boat restricted zone, 1990.

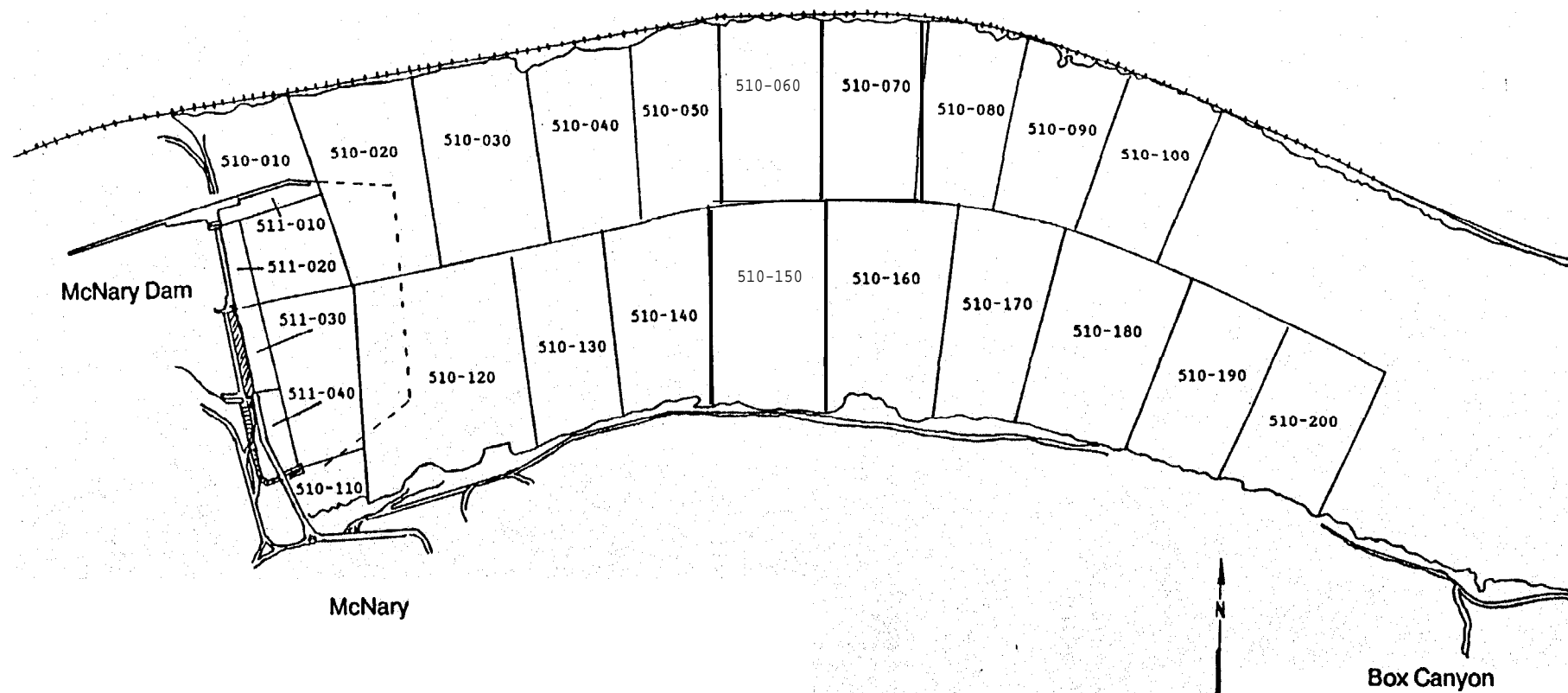


Figure A-13. Predator abundance indexing sampling locations and sampling location codes; McNary Dam forebay and boat restricted zone, 1990.

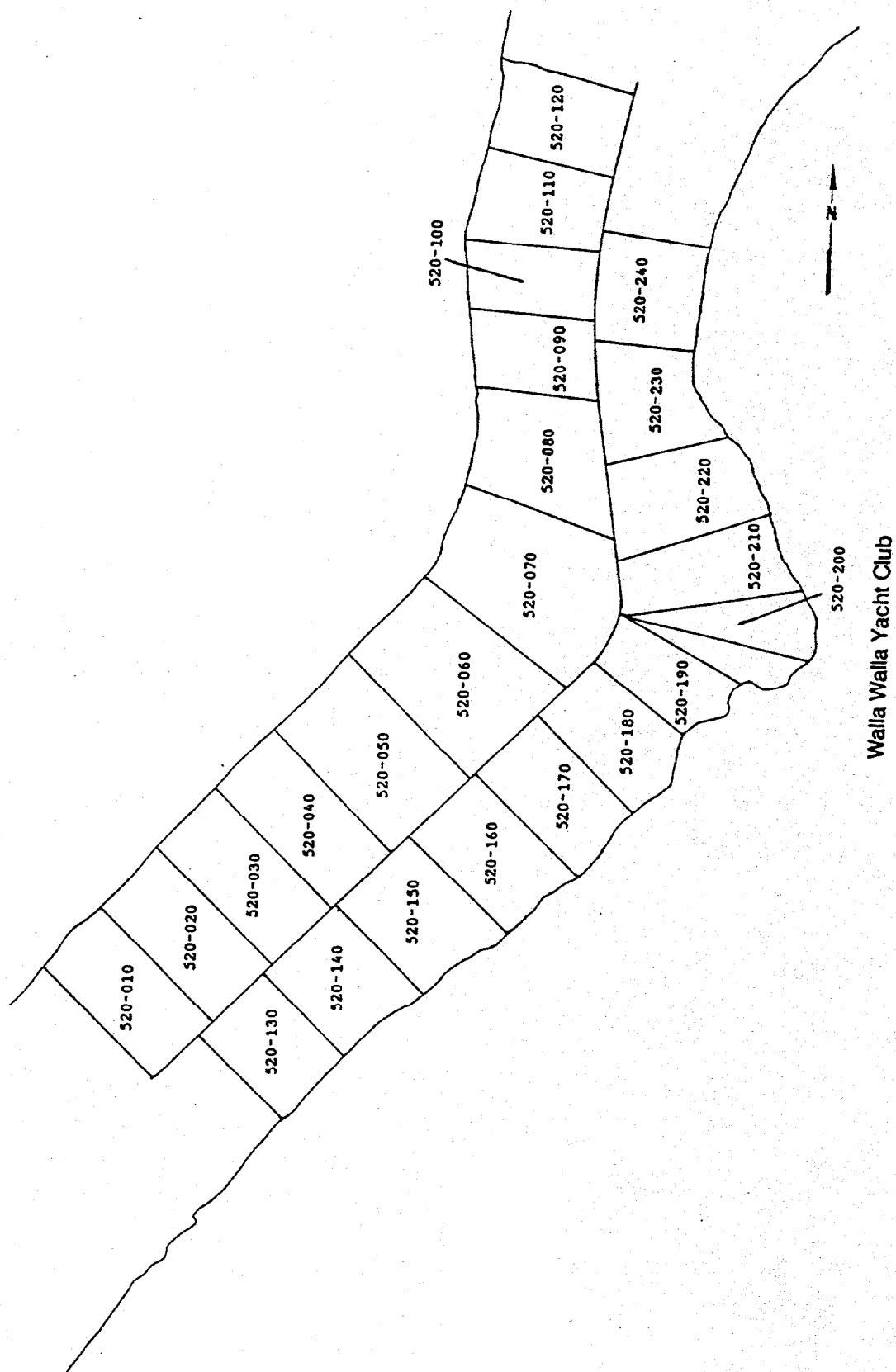


Figure A-14. Predator abundance indexing sampling locations and sampling location codes, mid-McNary Reservoir, 1990.

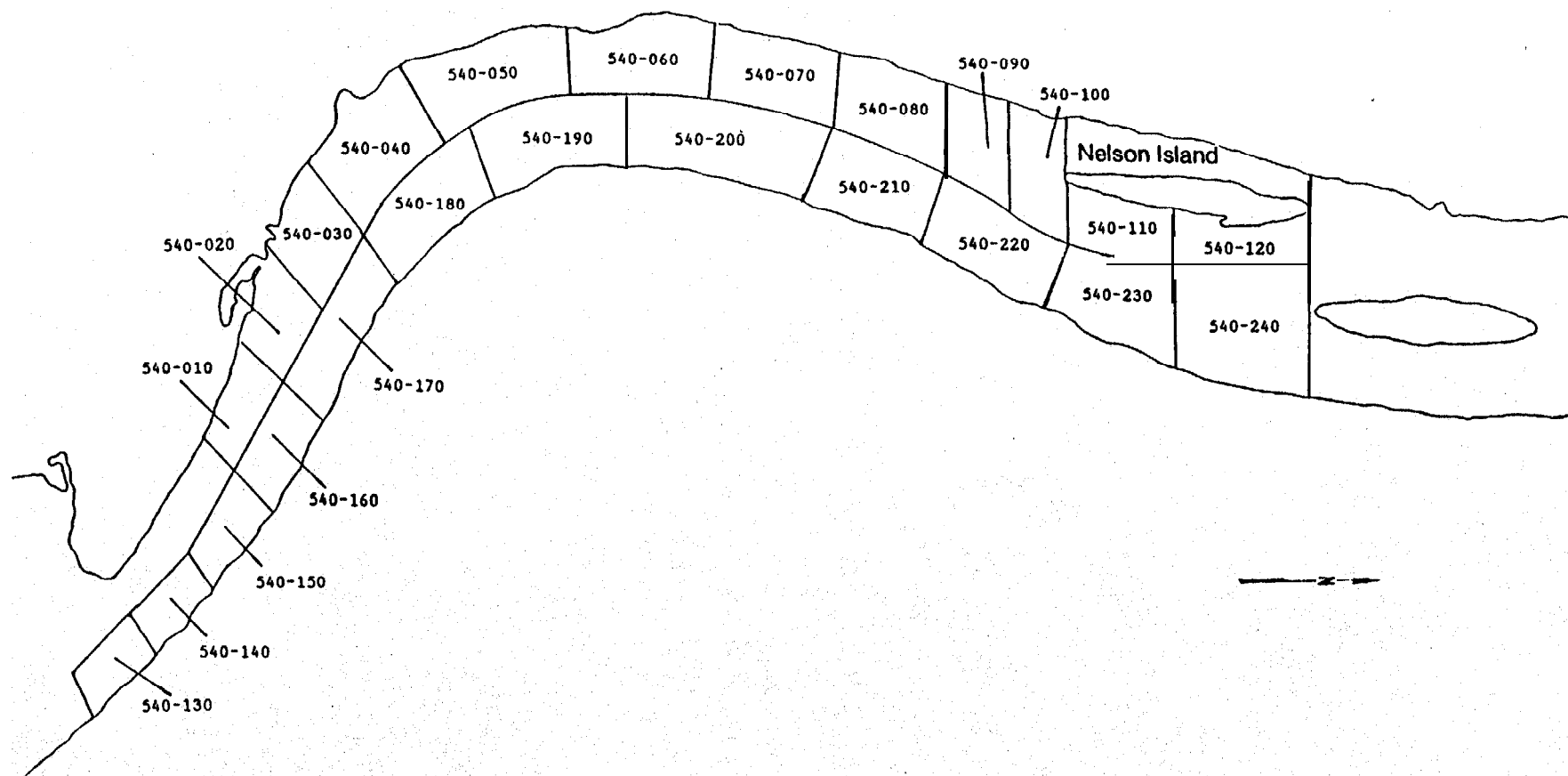


Figure A-15. predator abundance **indexing** sampling locations and sampling location **codes**, upper McNary Reservoir, 1990.

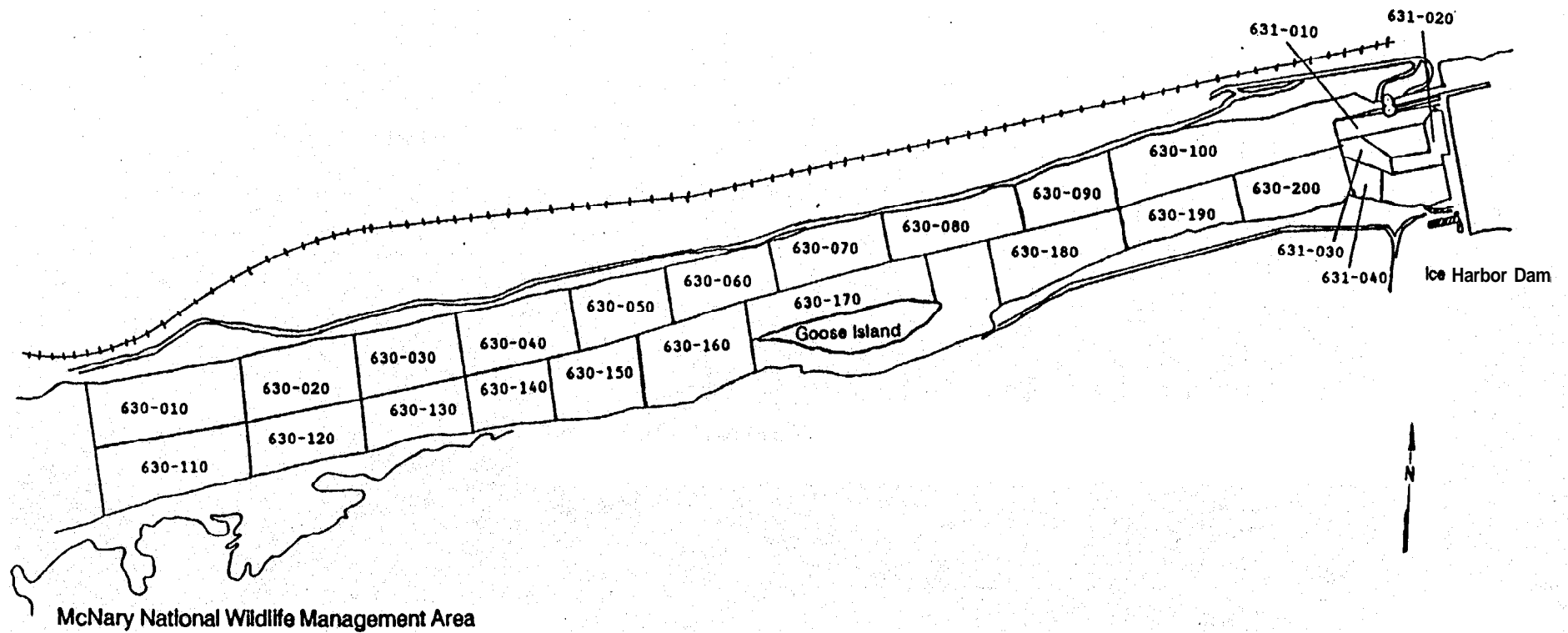


Figure A-16. Predator abundance indexing sampling locations and sampling location codes, Ice Harbor Dam tailrace and boat restricted zone, 1990.

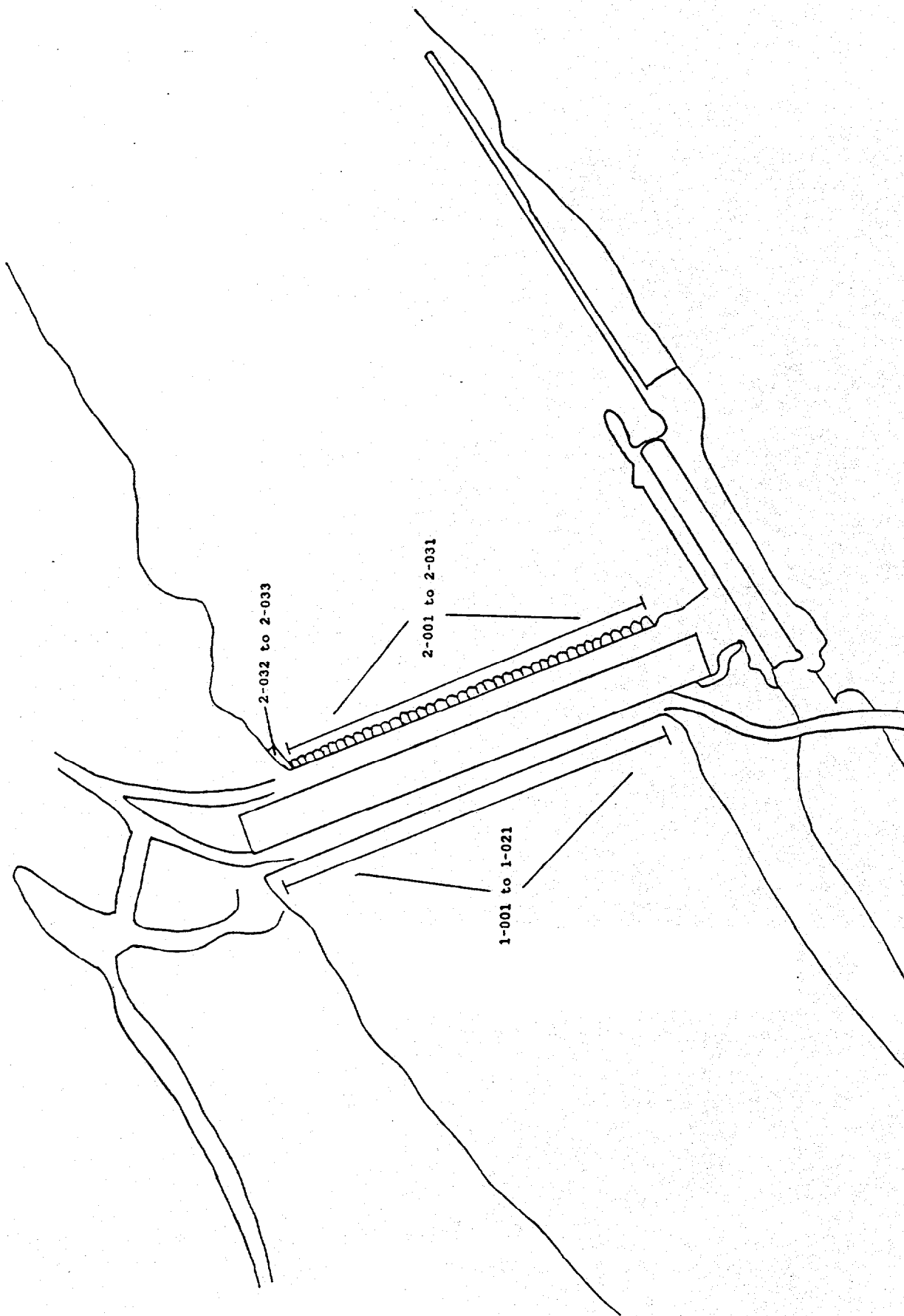


Figure A-17. Dam angling sampling locations and sampling location codes, Bonneville Dam Powerhouse 1, 1990.

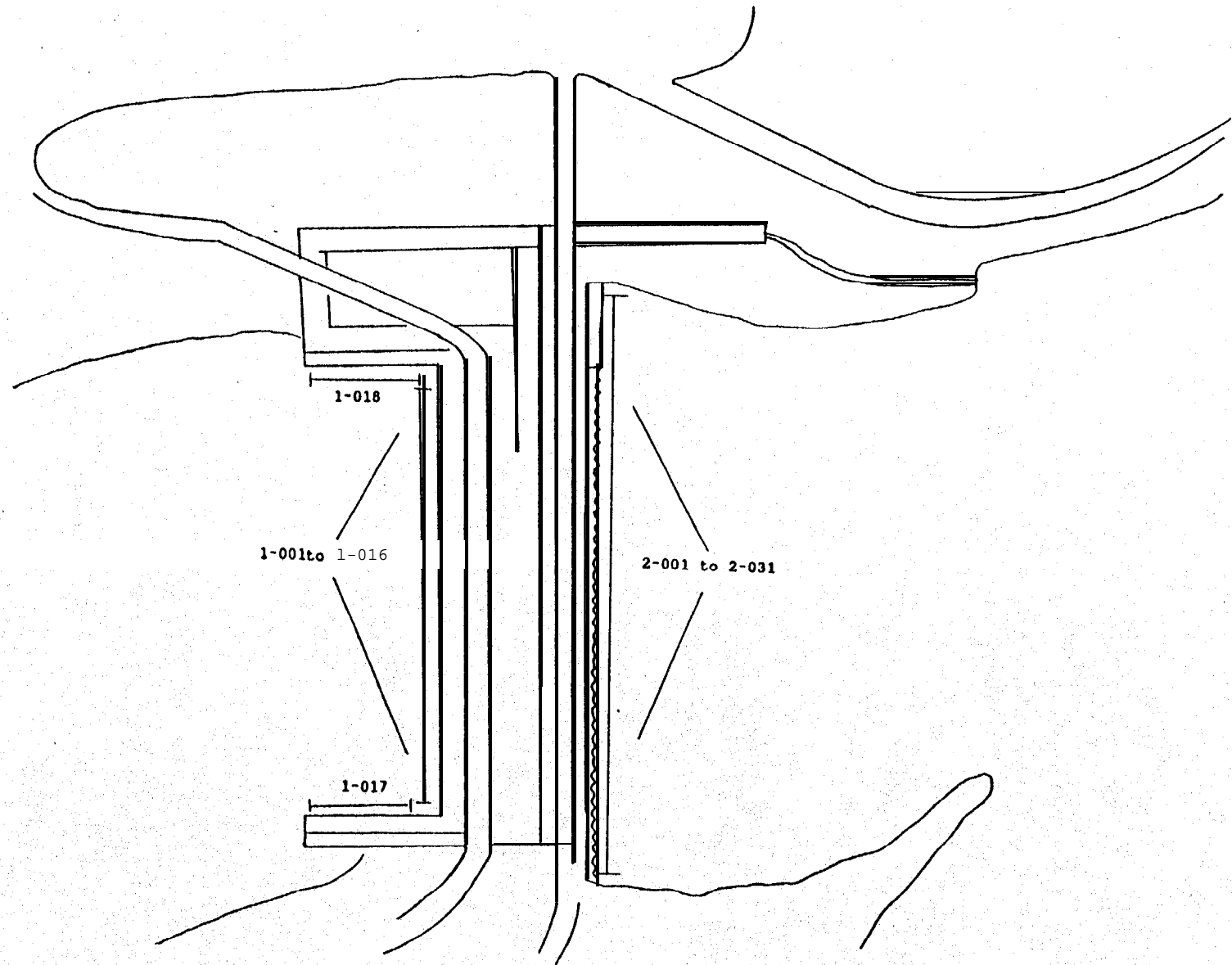


Figure A-18. Dam angling sampling locations and sampling location codes, Bonneville Dam Powerhouse 2, 1990.

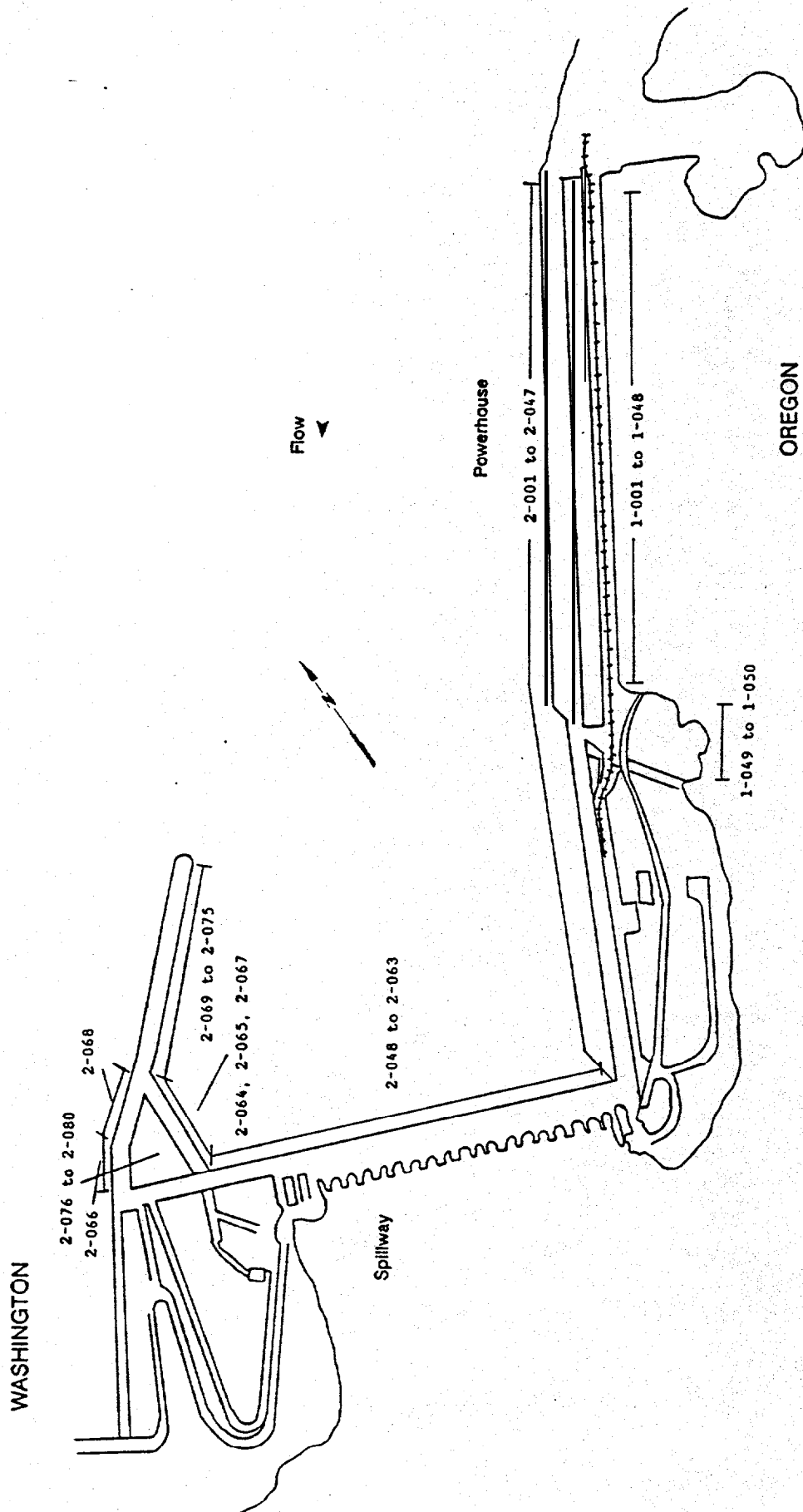


Figure A-19. Dam angling sampling locations and sampling location codes, The Dalles Dam, 1990.

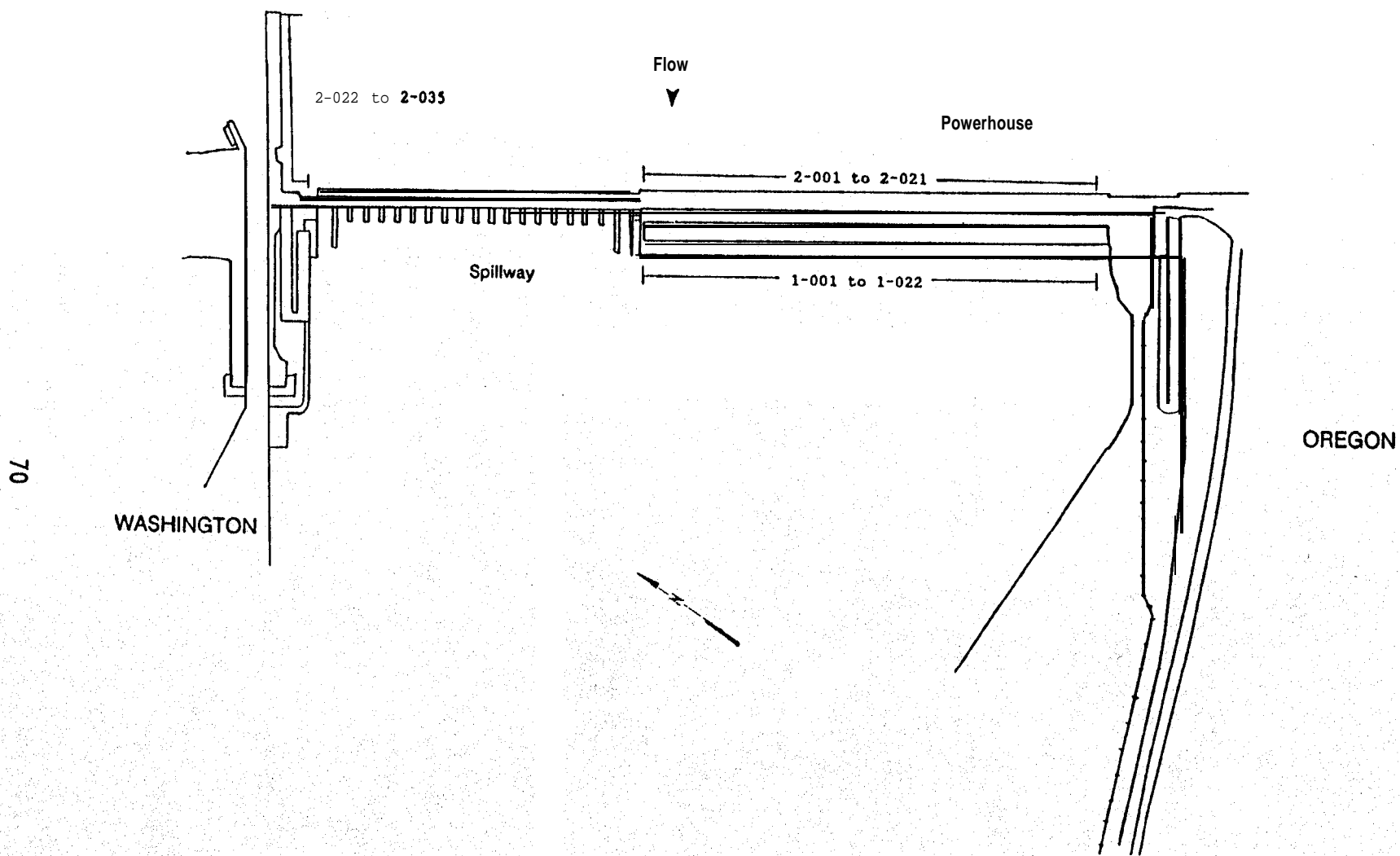


Figure A-20. Dam angling sampling locations and sampling location codes, John Day Dam, 1990.

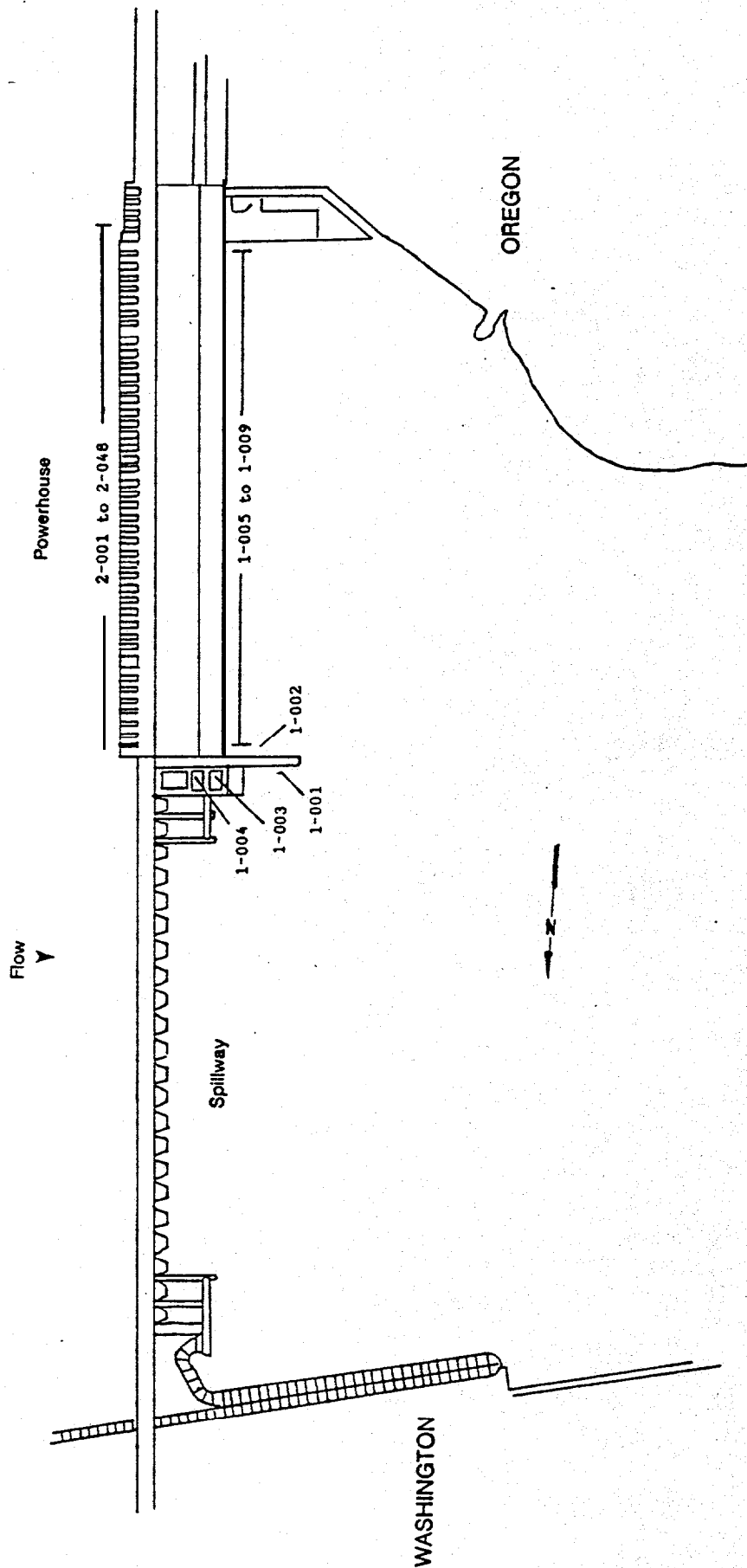


Figure A-21. Dam angling sampling locations and sampling location codes, McNary Dam, 1990.

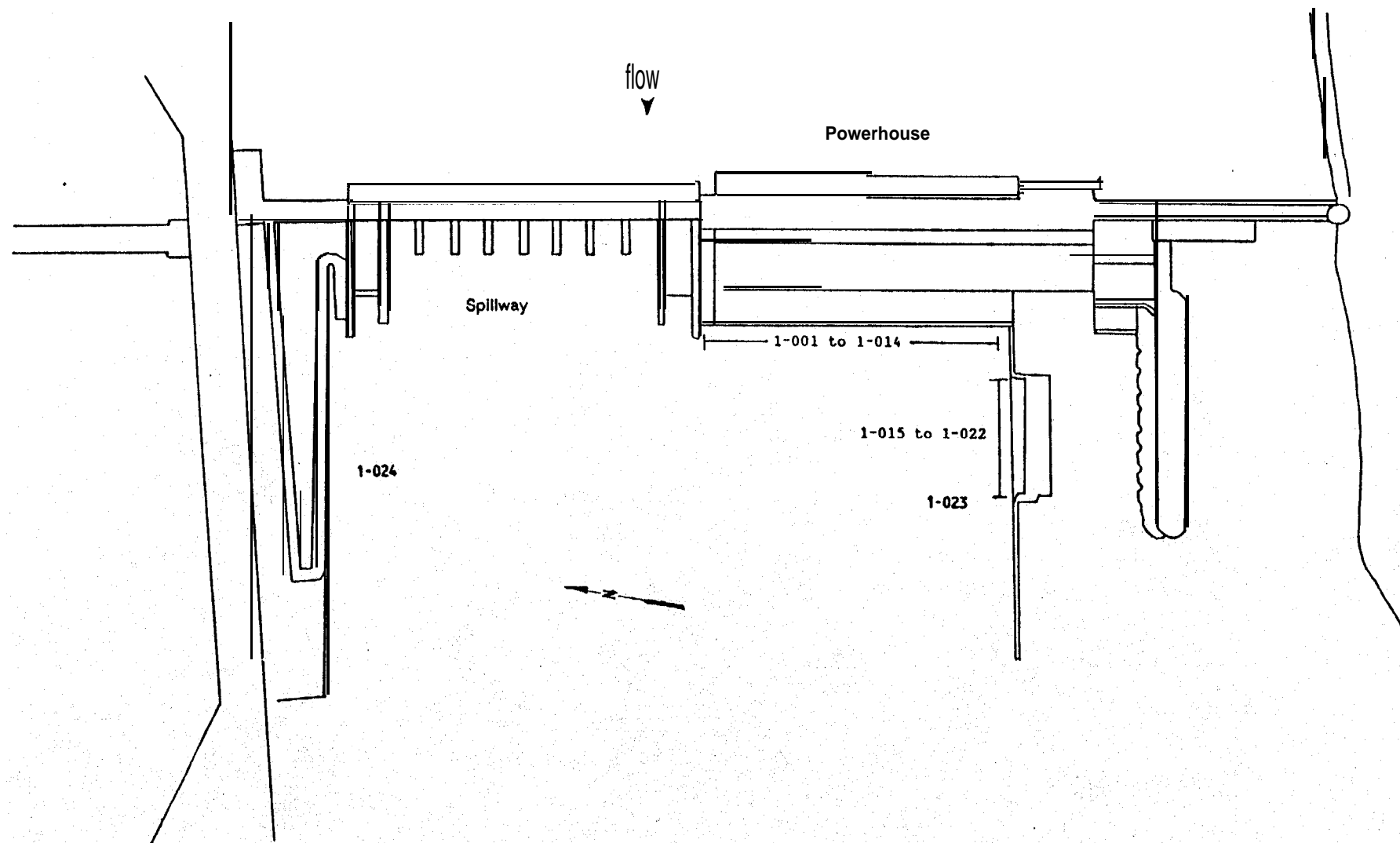


Figure A-22. Dam angling sampling locations and sampling location codes, Ice Harbor Dam, 1990.

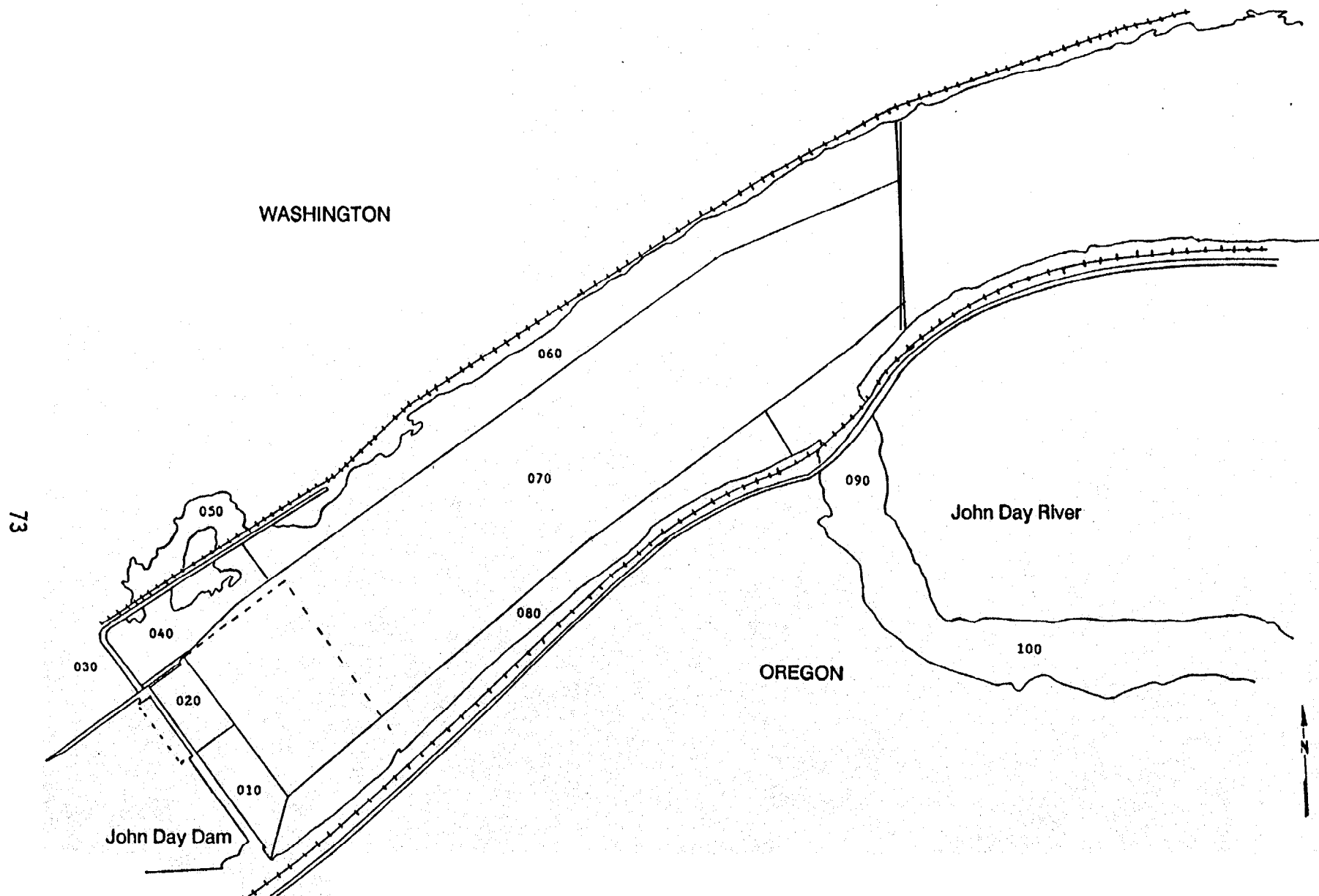


Figure A-23. Commercial **longline** fishery sampling locations and sampling location codes, John **Day** Dam forebay, 1990.

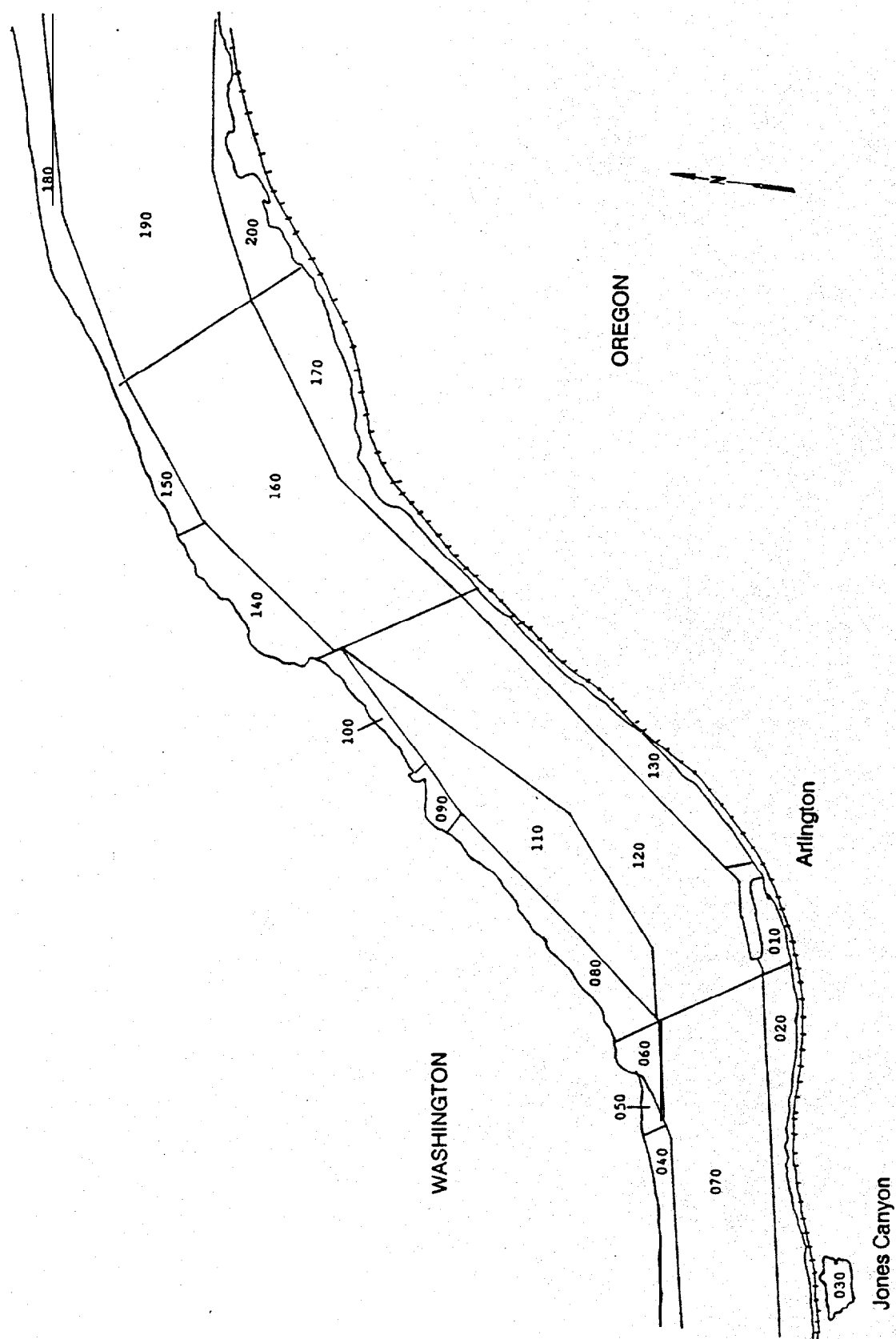


Figure A-24. Commercial longline fishery sampling locations and sampling location codes, Arlington, 1990

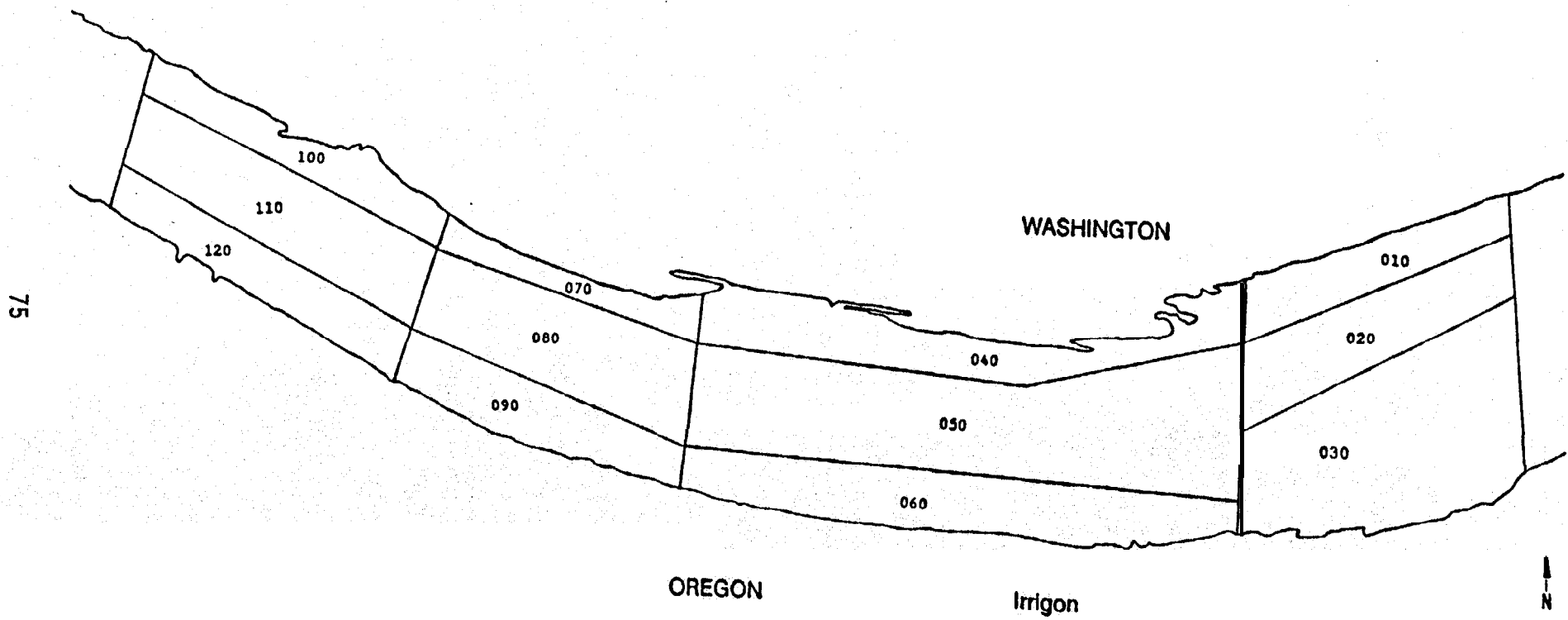


Figure A-25. Commercial **longline** fishery sampling locations and sampling location codes, Paterson (Irrigon), '1990.

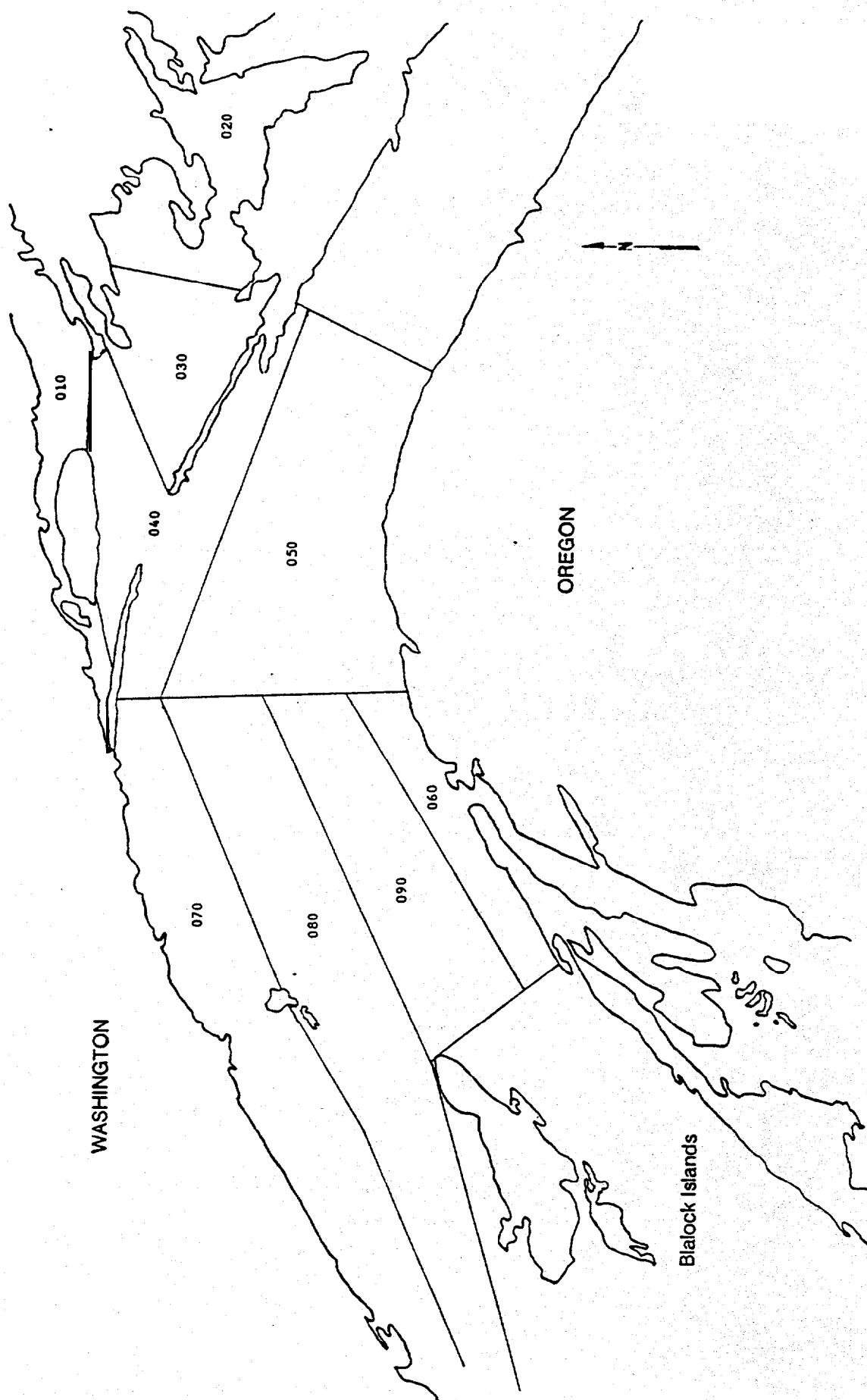


Figure A-26. Commercial longline fishery sampling locations and sampling location codes, Irrigon, 1990.

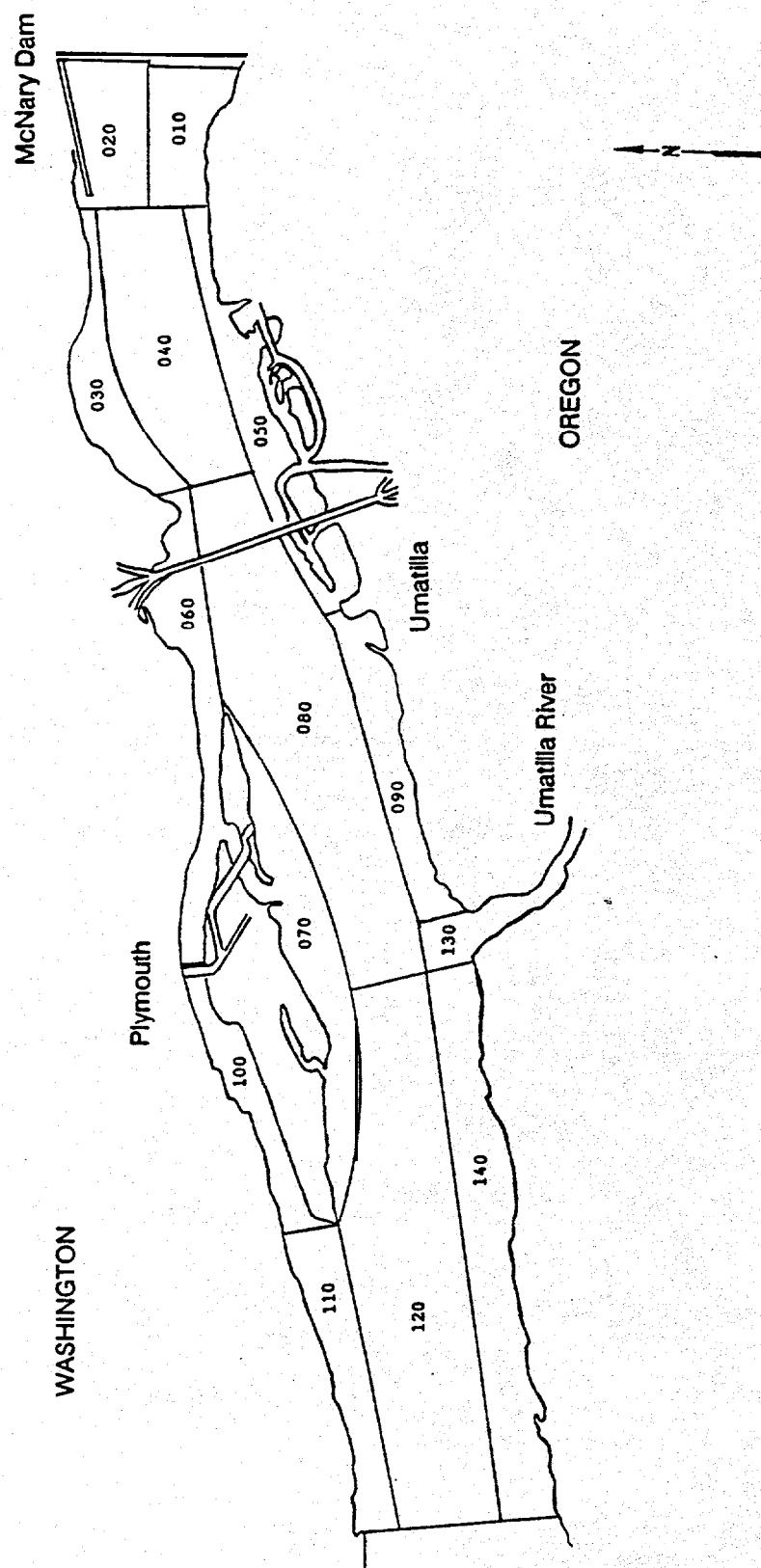


Figure A-27. Commercial longline fishery sampling locations and sampling location codes, Umatilla, 1990.

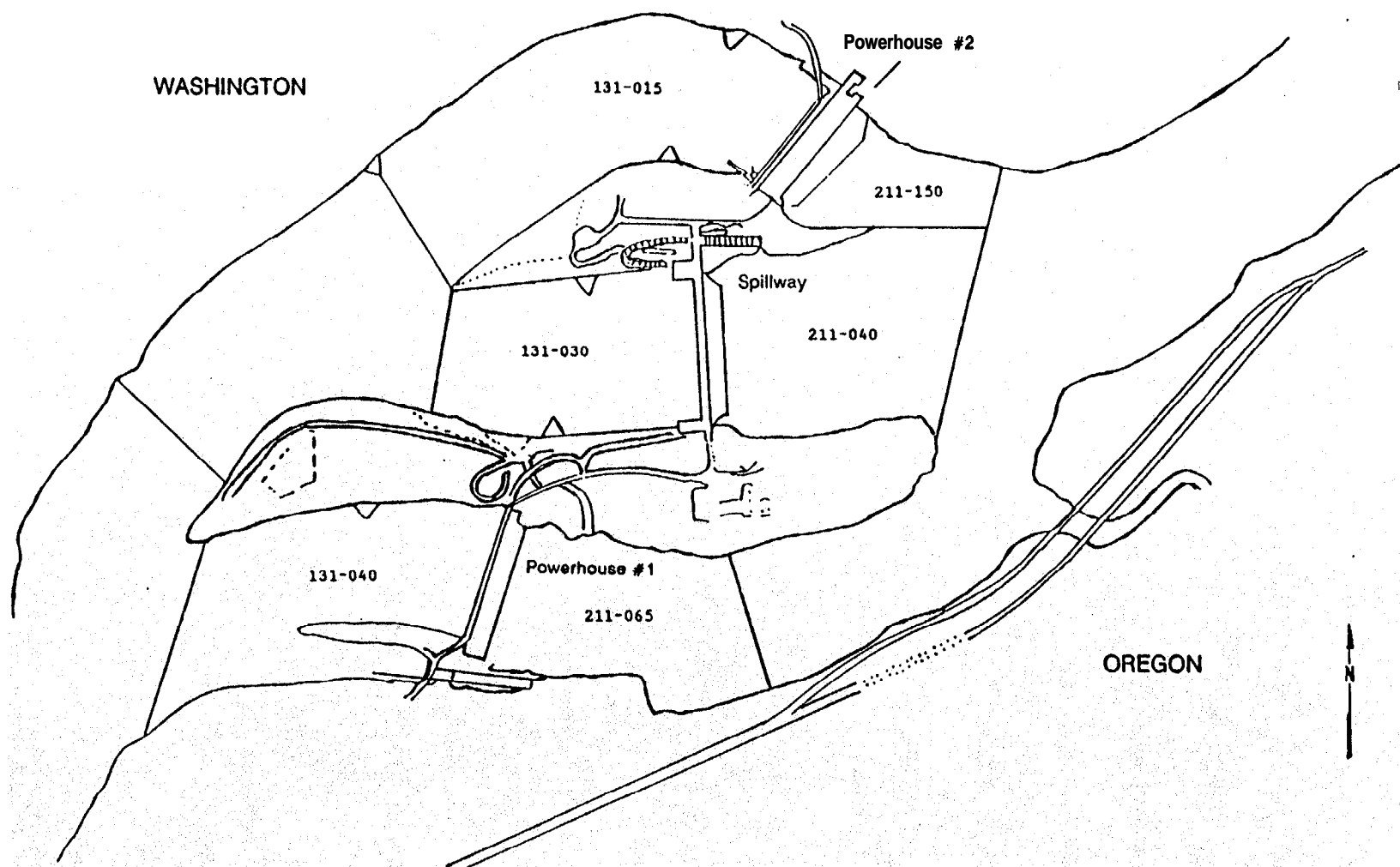


Figure A-28. Lure trolling study sampling locations and sampling location codes, Bonneville Dam **tailrace** and **forebay** boat restricted zones, 1990.

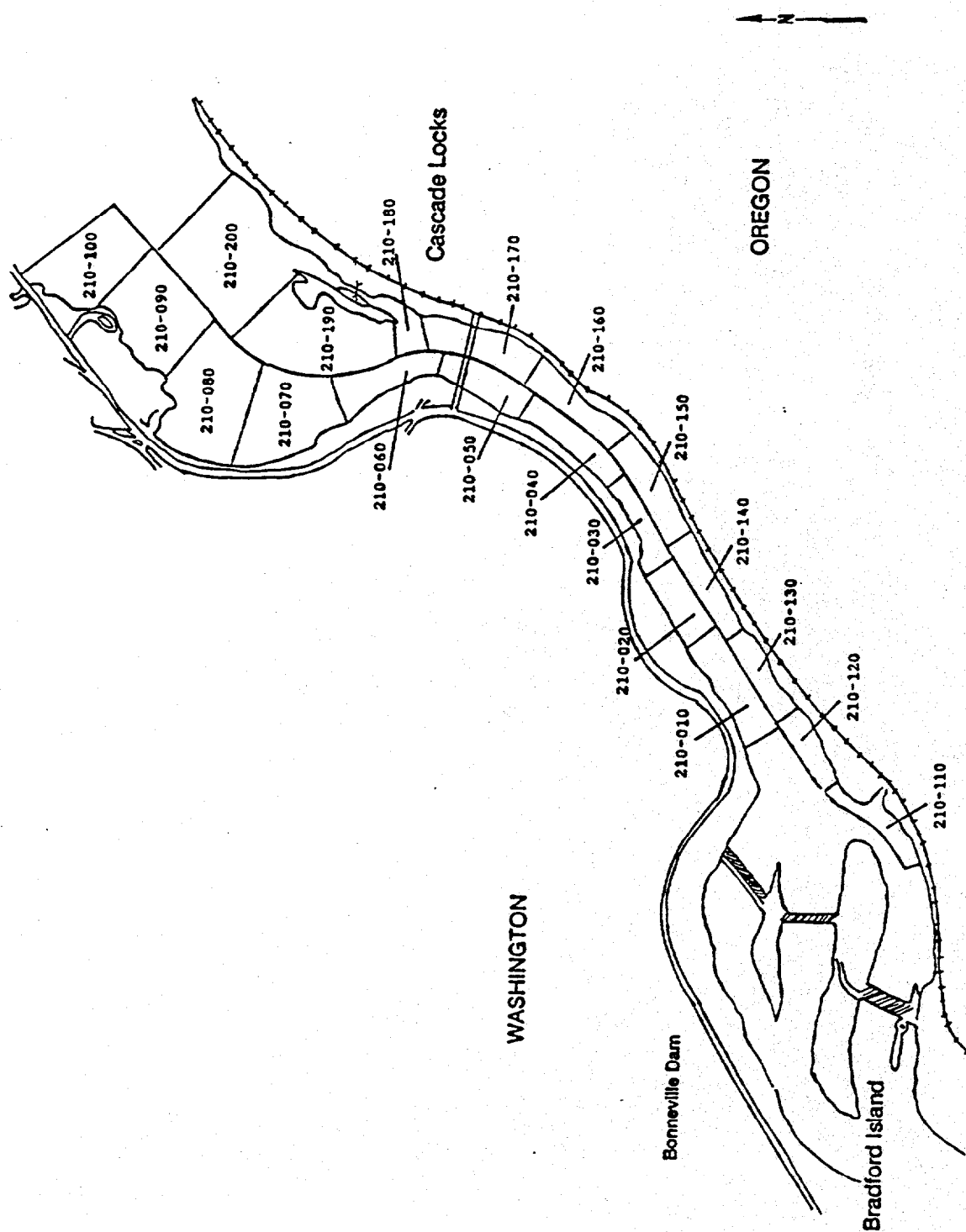


Figure A-29. Lure trolling study sampling locations and sampling location codes, Bonneville Dam forebay, 1990.

APPENDIX B. Weekly summaries of dam angling effort, northern squawfish catch,
and CPUE.

Table B-1. Weekly summary of effort, northern squawfish catch, and CPUE at Bonneville Dam Powerhouse 2 tailrace.

Month	Week (Monday)	Effort (angler hours)	Catch	Weekly CPUE
April	30	32	0	0.00
May	7	39	12	0.31
	14	--	--	--
	21	--	--	--
	28	36	5	0.14
June	4	30	15	0.50
	11	--	--	--
	18	--	--	--
	25	42	62	1.48
July	2	28	2	0.07
	9	--	--	--
	16	--	--	--
	23	34	14	0.41
	30	18	5	0.28
August	6	--	--	--
	13	49	15	0.31
	20	18	1	0.06
	27	24	4	0.17

Table B-2. Weekly summary of effort, northern squawfish catch, and CPUE at Bonneville Dam Powerhouse 2 forebay.

Month	Week (Monday)	Effort (angler hours)	Catch	Weekly CPUE
May	7	58	0	0.00
	14	81	13	0.16
	21	98	3	0.03
	28	38	8	0.21
June	4	51	16	0.31
	11	145	8	0.06
	18	74	8	0.11
	25	48	9	0.19
July	2	52	6	0.12
	9	72	5	0.07
	16	43	7	0.16
	23	20	2	0.10
	30	14	1	0.07
August	6	36	2	0.06
	13	47	9	0.19
	20	20	3	0.15
	27	--	--	--

Table B-3. Weekly summary of effort, northern squawfish catch, and CPUE at the Dalles Dam tailrace.

Month	Week (Monday)	Effort (angler hours)	Catch	Weekly CPUE
May	7	15	18	1.20
	14	24	13	0.54
	21	61	14	0.23
	28	48	25	0.52
June	4	48	40	0.83
	11	47	37	0.79
	18	40	9	0.23
	25	40	12	0.30
July	2	30	22	0.73
	9	40	39	0.98
	16	46	65	1.41
	23	47	55	1.17
	30	47	139	2.96
August	6	52	116	2.23
	13	49	148	3.02
	20	32	115	3.59
	27	35	132	3.77

Table B-4. Weekly summary of effort, northern squawfish catch, and CPUE at the Dalles Dam forebay.

Month	Week (Monday)	Effort (angler hours)	Catch	Weekly CPUE
May	7	2	0	0.00
	14	14	16	1.14
	28	28	7	0.25
June	4	12	2	0.17
	11	34	0	0.00
	18	32	1	0.03
	25	36	18	0.50
July	2	32	6	0.19
	9	40	15	0.38
	16	24	6	0.25
	23	30	30	1.00
	30	22	19	0.86
August	6	8	3	0.38
	13	8	14	1.75
	20	8	10	1.25
	27	--	--	--

Table B-5. Weekly summary of effort, northern squawfish catch, and CPUE at John Day Dam tailrace.

Month	Week (Monday)	Effort (angler hours)	Catch	Weekly CPUE
May	14	43	60	1.40
	21	73	97	1.33
	28	24	18	0.75
June	4	92	35	0.38
	11	97	8	0.08
	18	72	60	0.83
	25	56	91	1.63
July	2	28	56	2.00
	9	39	142	3.64
	16	26	105	4.04
	23	47	116	2.47
	30	38	148	3.89
August	6	36	150	4.17
	13	45	121	2.69
	20	51	66	1.29
	27	44	34	.77

Table B-6. Weekly summary of effort, northern squawfish catch, and CPUE at John Day Dam forebay.

Month	Week (Monday)	Effort (angler hours)	Catch	Weekly CPUE
June	25	16	0	0.00
July	2	32	1	0.03
	9	22	5	0.23
	16	18		0.17
	23	28		0.25
	30	30		0.00
August		46		0.02
	13	16		0.13
	20	36	12	0.33
	27	--	--	--

Table B-7. Weekly summary of effort, northern squawfish catch, and CPUE at McNary Dam tailrace.

Month	Week (Monday)	Effort (angler hours)	Catch	Weekly CPUE
April	30	37	94	2.54
May	7	88	75	0.85
	14	42	109	2.60
	21	32	159	4.97
	28	20	118	5.90
June	4	36	24	0.67
	11	34	69	2.03
	18	28	391	13.96
	25	30	498	16.60
July	2	14	274	19.57
	9	25	370	14.80
	16	22	397	18.05
	23	23	238	10.35
	30	32	275	8.59
August	6	40	236	5.90
	13	60	186	3.10
	20	60	259	4.32
	27	33	47	1.42

Table B-8. Weekly summary of effort, northern squawfish catch, and CPUE at McNary Dam forebay.

Month	Week (Monday)	Effort (angler hours)	Catch	Weekly CPUE
April	30	86	77	0.90
May	7	93	24	0.26
	14	90	38	0.42
	21	57	66	1.16
	28	28	23	0.82
June	4	30	8	0.27
	11	32	12	0.38
	18	36	37	1.03
	25	16	11	0.69
July	2	12	18	1.50
	9	26	43	1.65
	16	8	10	1.25
	23	24	53	2.21
	30	32	72	2.25
August	6	14	16	1.14
	13	16	4	0.25
	20	24	38	1.58
	27	14	17	1.21

Table B-9. Weekly summary of effort, northern squawfish catch, and CPUE at Ice Harbor Dam tailrace.

Month	Week (Monday)	Effort (angler hours)	Catch	Weekly CPUE
May	21	8	3	0.38
	28	28	6	0.21
June	4	32	3	0.09
	11	30	3	0.10
	18	22	8	0.36
	25	28	41	1.46
July	2	34	145	4.26
	9	34	32	0.94
	16	24	54	2.25
	23	32	29	0.91
	30	34	12	0.35
August	6	28	110	3.93
	13	20	47	2.35
	20	26	21	0.81
	27	20	13	0.65

APPENDIX C. Temporal trends in CPUE of northern squawfish by dam angling at each forebay and tailrace sampled.

Table C-1. Weekly summary of northern squirefish CPUE by location, 1990.

Week	Date (Monday)	Dam area											
		Bonneville Powerhouse 1		Bonneville Powerhouse 2		The Dalles		John Day		McNary		Ice Harbor	
		Tailrace	Forebsy	Tailrace	Forebsy	Tailrace	Forebay	Tailrace	Forebay	Tailrace	Forebsy	Tailrace	
1	30 April	--	--	0.00	--	--	--	--	--	2.54	0.90	--	
2	07 May	0.48	0.05	0.31	0.00	1.20	0.00	--	--	0.85	0.26	--	
3	14 May	--	0.36	--	0.16	0.54	1.14	1.40	--	2.60	0.42	--	
4	21 May	--	0.28	--	0.03	0.23	--	1.30	--	4.97	1.16	0.38	
5	28 May	1.20	5.08	0.14	0.21	0.52	0.25	0.75	--	5.90	0.82	0.21	
6	04 June	0.58	3.11	0.50	0.31	0.83	0.17	0.38	--	0.67	0.27	0.09	
7	11 June	--	0.79	--	0.06	0.79	0.00	0.08	--	2.03	0.38	0.11	
a	18 June	--	3.17	--	0.11	0.23	0.03	0.83	--	13.96	1.03	0.36	
9	25 June	3.77	4.45	1.48	0.19	0.30	0.50	1.63	0.00	16.80	0.69	1.46	
10	02 July	3.40	5.64	0.07	0.12	0.73	0.19	2.00	0.03	19.57	1.50	4.26	
11	09 July	--	3.41	--	0.07	0.98	0.38	3.64	0.23	14.80	1.65	0.94	
12	16 July	--	3.69	--	0.16	1.41	0.25	4.04	0.17	18.05	1.25	2.25	
13	23 July	6.09	5.66	0.41	0.10	1.17	1.00	2.47	0.25	10.35	2.21	0.91	
14	30 July	4.05	6.52	0.28	0.07	2.96	0.86	3.89	0.00	8.59	2.25	0.35	
15	06 August	1.35	3.31	--	0.06	2.23	0.36	4.17	0.02	5.90	1.14	3.93	
16	13 August	2.50	2.19	0.31	0.19	3.02	1.75	2.69	0.13	3.10	0.25	2.35	
17	20 August	0.92	1.98	0.06	0.15	3.59	1.25	1.29	0.33	4.32	1.58	0.81	
18	27 August	1.03	0.93	0.17	--	3.77	--	0.77	--	1.42	1.21	0.65	

APPENDIX D. Weekly summaries of sport-reward fishery effort, northern squawfish catch, and CPUE.

Table D-1. Weekly summary of effort, northern squawfish catch, and CPUE at Plymouth Marina.

Week ending	Number of Anglers			Hours per Angler	Total Angler Hours	≥ 11" Total length			< 11" Total length		
	Initial Register	Exit Interview	Total in Group			Catch	Fish per hr	Fish per Angler	Catch	Fish per hr	Fish per Angler
28 May	57	17	35	4.64	163	11	0.07	0.31	0	0.00	0.00
03 June	19	5	10	5.25	53	10	0.19	1.00	2	0.04	0.20
10 June	22	9	17	2.68	46	1	0.02	0.06	0	0.00	0.00
17 June	26	13	18	4.17	75	4	0.05	0.22	1	0.01	0.06
24 June	32	14	33	5.23	173	a	0.05	0.24	0	0.00	0.00
01 July	27	11	26	5.62	146	23	0.16	0.88	0	0.00	0.00
08 July	49	22	38	4.69	178	25	0.14	0.66	3	0.02	0.08
15 July	28	11	20	5.54	111	a	0.07	0.40	0	0.00	0.00
22 July	78	43	95	5.37	511	153	0.30	1.61	6	0.01	0.06
29 July	44	19	49	4.69	230	29	0.13	0.59	1	0.00	0.02
05 August	54	18	39	6.04	236	12	0.05	0.31	0	0.00	0.00
12 August	38	12	24	6.00	144	23	0.16	0.01	0	0.00	0.00
19 August	28	13	24	5.28	127	15	0.12	0.63	0	0.00	0.00
26 August	53	13	22	5.32	117	24	0.21	1.09	0	0.00	0.00
03 September	47	22	55	5.53	304	42	0.14	0.76	0	0.00	0.00

Table D-2. Weekly summary of effort, northern squawfish catch, and CPUE at Umetilla Marine.

Week ending	Number of Anglers			Hours per Angler	Total Angler Hours	≥ 11" Total length			< 11" Total length			per ,
	Initial Register	Exit Interview	Total in Group			Catch	Fish per hr	Fish per Angler	Catch	Fish per hr	Fish per Angler	
28 May	40	24	24	3.63	87	26	0.30	1.08	3	0.03	0.13	
03 June	13	7	8	3.38	27	9	0.33	1.13	0	0.00	0.00	
10 June	32	12	15	3.18	48	33	0.69	2.20	0	0.00	0.00	
17 June	24	1a	26	3.62	94	22	0.23	0.85	4	0.04	0.15	
24 June	44	19	24	2.97	71	73	1.02	3.04	1	0.01	0.04	
01 July	40	25	41	3.64	149	156	1.05	3.80	0	0.00	0.00	
08 July	23	9	14	3.05	43	35	0.82	2.50	1	0.02	0.07	
15 July	11	a	14	2.96	42	20	0.48	1.43	0	0.00	0.00	
22 July	88	30	48	4.57	219	149	0.68	3.10	2	0.01	0.04	
29 July	al	1a	37	4.72	175	80	0.46	2.16	6	0.03	0.16	
05 August	56	13	24	4.23	102	62	0.61	2.58	0	0.00	0.00	
12 August	67	27	53	5.57	295	151	0.51	2.85	0	0.00	0.00	
19 August	90	30	63	5.33	336	134	0.40	2.13	1	0.00	0.02	
26 August	68	17	43	5.31	229	70	0.31	1.63	0	0.00	0.00	
03 September	75	41	79	5.25	415	151	0.36	1.91	0	0.00	0.00	

Table D-3. Weekly summary of effort, northern squawfish catch, and CPUE at Arlington Marina.

Week ending	Number of Anglers			Hours per Angler	Total Angler Hours	≥ 11" Total length			< 11" Total length		
	Initial Register	Exit Interview	Total in Group			Catch	Fish per hr	Fish per Angler	Catch	Fish per hr	Fish per Angler
28 May	21	5	10	2.68	27	0	0.00	0.00	0	0.00	0.00
03 June	11	1	2	7.00	14	1	0.07	0.50	0	0.00	0.00
10 June	4	2	5	5.00	25	0	0.00	0.00	0	0.00	0.00
17 June	5	1	1	3.00	3	0	0.00	0.00	0	0.00	0.00
24 June	10	10	15	4.00	60	0	0.00	0.00	0	0.00	0.00
01	6	4	4	2.50	10	0	0.00	0.00	0	0.00	0.00
08 July	5	2	2	4.00	a	0	0.00	0.00	0	0.00	0.00

Table D-4. Weekly summary of effort, northern squawfish catch, and CPUE at Le Page Marina (John Day Dam forebay).

Week ending	Number of Anglers			Hours per Angler	Total Angler Hours	≥ 11" Total length			< 11" Total length		
	Initial Register	Exit Interview	Total in Group			Catch	Fish per hr	Fish per Angler	Catch	Fish per hr	Fish per Angler
28 May	74	10	24	4.15	99	35	0.35	1.46	1	0.01	0.04
03 June	37	4	14	7.54	105	13	0.12	0.93	0	0.00	0.00
10 June	23	2	7	2.14	15	3	0.20	0.43	0	0.00	0.00
17 June	37	4	8	6.00	48	15	0.31	1.88	0	0.00	0.00
24 June	44	7	16	4.94	79	15	0.19	0.94	0	0.00	0.00
01 July	43	9	18	6.00	108	42	0.39	2.33	0	0.00	0.00
08 July	26	7	12	2.75	33	17	0.52	1.42	0	0.00	0.00
15 July	17	2	2	6.00	12	7	0.58	3.50	0	0.00	0.00
22 July	143	11	18	6.83	123	25	0.20	1.39	0	0.00	0.00
29 July	139	31	54	8.78	474	376	0.79	6.96	1	0.00	0.02
05 August	131	26	43	6.74	290	401	1.39	9.33	0	0.00	0.00
12 August	111	34	71	6.08	432	493	1.14	6.94	7	0.02	0.10
19 August	81	40	45	6.03	272	587	2.16	13.04	1	0.00	0.02
26 August	74	35	60	6.63	398	441	1.11	7.35	0	0.00	0.00
03 September	52	31	55	7.60	418	676	1.62	12.29	0	0.00	0.00

APPENDIX E. Weekly summaries of commercial longline fishery effort, northern squawfish and incidental catch, and CPUE.

Table E-1. Weekly summary of effort, catch, and CPUE at Umatilla Marina. SQF = northern squawfish, SMB = smallmouth bass, UAL = walleye, CHC = channel catfish.

Month	Week (Monday)	Fisherman	Effort (sets)	Species				CPUE			
				SQF	SMB	UAL	CHC	SQF	SMB	UAL	CHC
June	11	Williams	23	28	0	0	16	1.22	0.00	0.00	0.70
	18	Hoptouit	41	164	1	0	10	4.00	0.02	0.00	0.24
	25	Blevins	44	97	0	1	7	2.20	0.00	0.02	0.16
July	2	Williams	38	95	0	0	4	2.50	0.00	0.00	0.11
	9	Hoptouit	34	117	0	0	1	3.44	0.00	0.00	0.03
	16	Blevins	22	17	0	0	4	0.77	0.00	0.00	0.18
	23	Williams	a	5	0	0	1	0.63	0.00	0.00	0.13
	30	Hoptouit	33	51	0	0	1	1.55	0.00	0.00	0.03
August	6	Blevins	23	32	0	0	2	1.39	0.00	0.00	0.09

Table E-2. Weekly summary of effort, catch, and CPUE at Irrigon Marina. SQF = northern squawfish, SMB = smallmouth bass, UAL = walleye, CHC = channel catfish.

Month	Week (Monday)	Fisherman	Effort (sets)	Species				CPUE			
				SQF	SMB	UAL	CHC	SQF	SMB	UAL	CHC
June	11	Blevins	34	57	0	0	25	1.68	0.00	0.00	0.74
	18	Williams	33	61	0	0	23	1.85	0.02	0.00	0.70
	25	Hoptouit	29	129	7	0	16	4.45	0.24	0.00	0.55
July	2	Blevins	37	108	0	0	13	2.92	0.00	0.00	0.35
	9	Williams	29	45	0	0	a	1.55	0.00	0.00	0.28
	16	Hoptouit	15	25	0	0	5	1.67	0.00	0.00	0.33
	23	Blevins	14	13	0	0	3	0.93	0.00	0.00	0.21
	30	Williams	11	12	0	0	5	1.09	0.00	0.00	0.45
August	6	Hoptouit	19	46	0	0	15	2.42	0.00	0.00	0.79

Table E-3. Weekly summary of effort, catch, and CPUE at Arlington Marina. SQF = northern squawfish, SMB = smallmouth bass, UAL = walleye, CHC = channel catfish.

Month	Week (Monday)	F i s h e r m a n	Effort (sets)	Species				CPUE			
				SQF	SMB	UAL	CHC	SQF	SMB	UAL	CHC
June	11	Hoptoui t	42	66	0	0	2	1.57	0.00	0.00	0.05
	18	Blevins	31	45	0	0	2	1.45	0.02	0.00	0.06
	25	Williams	17	6	0	0	0	0.35	0.00	0.00	0.00
July	2	Hoptoui t	53	63	0	0	2	1.19	0.00	0.00	0.04
	9	Blevins	33	73	0	0	4	2.21	0.00	0.00	0.12
	16	Williams	9	4	0	0	1	0.44	0.00	0.00	0.11
	23	Hoptoui t	14	21	0	0	3	1.50	0.00	0.00	0.21
	30	Blevins	26	40	0	0	9	1.54	0.00	0.00	0.35
August	6	Williams

APPENDIX F. Summaries of index sampling effort, northern squawfish catch, and CPUE.

Table F-1. Summary of ODFW electrofishing effort, northern squawfish catch, and CPUE, early period (30 April - 13 July), 1990. Each unit of effort was comprised of a 15 minute shocking run.

Reservoir	Catch by area			Total catch	Effort	CPUE
	Tailrace	Middle	Forebay			
Ice Harbor ^a	116	--	--	116	12	9.67
McNary	27	3	0	30	45	0.67
John Day	48	2	13	63	41	1.54
The Dalles	57	0	14	71	33	2.15
Bonneville	32	60	77	169	45	3.76
Bonneville ^a	20	--	--	20	6	3.33

^a Sampling was limited to the tailrace area immediately downstream from the dam specified.

Table F-2. Summary of ODFW bottom gillnet effort, northern squawfish catch, and CPUE, early period (30 April - 13 July), 1990. Each unit of effort was comprised of a one hour net set.

Reservoir	Catch by area			Total catch	Effort	CPUE
	Tailrace	Middle	Forebay			
Ice Harbor ^a	3	--	--	3	8	0.38
JohnrDay	19	2	5	16	25	0.64
The Dalles	22	21	16	59	32	1.84
Bonneville	4	10	31	45	30	1.50
Bonneville ^a	15	--	--	15	3	5.00

^a sampling was limited to the tailrace area immediately downstream from the dam specified.

Table F-3. Summary of ODFW surface gillnet effort, northern squawfish catch, and CPUE, early period (30 April - 13 July), 1990. Each unit of effort was comprised of a one hour net set.

Reservoir	Catch by area			Total catch	Effort	CPUE
	Tailrace	Middle	Forebay			
Ice Harbor ^a	0	--	--	0	6	0.00
McNary	13	4	5	22	32	0.69
John Day	2	5	3	10	25	0.40
The Dalles	21	2	8	31	32	0.97
Bonneville	4	4	2	10	28	0.36
Bonneville ^a	0	--	--	0	2	0.00

^a Sampling was limited to the tailrace area immediately downstream from the dam specified.

Table F-4. Summary of USFWS electrofishing effort, northern squawfish catch, and CPUE, early period (30 April - 13 July), 1990. Each unit of effort was comprised of a 15 minute shocking run.

Reservoir	Catch by area			Total catch	Effort	CPUE
	Tailrace	Middle	Forebay			
Ice Harbor ^a	14	--	--	14	17	0.82
McNary	33	8	24	65	59	1.10
John Day	84	6	36	126	60	2.10
The Dalles	100	15	38	153	57	2.68
Bonneville	45	41	103	189	57	3.32
Bonneville ^a	161	--	--	161	12	13.42

^a Sampling was limited to the tailrace area immediately downstream from the dam specified.

Table F-5. Summary of ODFW electrofishing effort, northern squawfish catch, and CPUE, late period (16 July - 31 August), 1990. Each unit of effort was comprised of a 15 minute shocking run.

Reservoir	Catch by area			Total catch	Effort	CPUE
	Tailrace	Middle	Forebay			
Ice Harbor ^a	8	--	--	8	19	0.42
McNary	26	2	2	30	60	0.50
John Day	14	11	22	47	56	0.84
The Dalles	103	12	15	130	47	2.77
Bonneville	20	28	86	134	35	3.83
Bonneville ^a	196	--	--	196	10	19.60

^a Sampling was limited to the tailrace area immediately downstream from the dam specified.

Table F-6. Summary of ODFW bottom gillnet effort, northern squawfish catch, and CPUE, late period (16 July - 31 August), 1990. Each unit of effort was comprised of a one hour net set.

Reservoir	Catch by area			Total catch	Effort	CPUE
	Tailrace	Middle	Forebay			
Ice Harbor ^a	0	--	--	0	20	0.00
McNary	3	2	6	11	58	0.19
John Day	5	12	5	22	57	0.39
The Dalles	14	3	15	32	42	0.76
Bonneville	18	18	15	51	34	1.50
Bonneville ^a	55	--	--	55	7	7.86

^a Sampling was limited to the tailrace area immediately downstream from the dam specified.

Table F-7. Summary of ODFW surface gillnet effort, northern squawfish catch, and CPUE, late period (16 July - 31 August), 1990. Each unit of effort was comprised of a one hour net set.

Reservoir	Catch by area			Total catch	Effort	CPUE
	Tailrace	Middle	Forebay			
Ice Harbor ^a	3	--	--	3	17	0.18
McNary	1	1	2	4	53	0.08
John Day	5	6	7	18	59	0.31
The Dalles	11	0	5	16	39	0.41
Bonneville	11	3	4	18	34	0.53
Bonneville ^a	5	--	--	5	5	1.00

^a Sampling was limited to the tailrace area immediately downstream from the dam specified.

Table F-8. Summary of USFWS electrofishing effort, northern squawfish catch, and CPUE, late period (25 June - 26 July), 1990. Each unit of effort was comprised of a one hour net set.

Reservoir	Catch by area			Total catch	Effort	CPUE
	Tailrace	Middle	Forebay			
Ice Harbor ^a	147	--	--	147	19	7.74
McNary	50	14	6	70	69	1.01
John Day	150	7	15	172	62	2.77
The Dalles	147	51	61	259	59	4.39
Bonneville	60	48	174	282	72	3.92
Bonneville ^a	238	--	--	238	21	11.33

^a Sampling was limited to the tailrace area immediately downstream from the dam specified.

Appendix G. Summaries of incidental catch of non-target fish species.

Table G-1. Summary of incidental catch during dam angling.

Family, species, and common name	Dam					
	Bonneville Powerhouse 1	Bonneville Powerhouse 2	The Dalles	John Day	McNary	Ice Harbor
Petromyzontidae:						
Entosphenus tridentatus Pacific lamprey	0	0	0	0	0	0
Acipenseridae:						
Acipenser transmontanus White sturgeon	6	36	2	5	10	0
Clupeidae:						
Alosa sapidissima American shad	28	0	0	3	7	1
Salmonidae:						
Oncorhynchus tshawytscha Chinook salmon	0	0	0	0	1	0
Oncorhynchus mykiss Rainbow trout	3	0	1	4	11	0
Cyprinidae:						
Cyprinus carpio Carp	0	0	0	0	0	1
Catostomidae:						
Catostomus spp. Suckers	0	0	0	0	1	0
Ictaluridae:						
Ictalurus punctatus Channel catfish	1	2	4	10	17	260
Gasterosteidae:						
Gasterosteus aculeatus Threespine stickleback	0	0	0	0	0	0
Percopsidae:						
Percopsis transmontanus Sand roller	0	0	0	0	0	0
Centrarchidae:						
Micropterus dolomieu Smallmouth bass	0	0	13	1	10	1
Micropterus salmoides Largemouth bass	0	0	3	0	0	0

Table G-1. (Continued)

Fami Ly, species, and common name	Dam					
	Bonneville Powerhouse 1	Bonneville Pouerhouse 2	The Dal les	John Day	McNary	Ice Harbor
Percidae:						
Stizostedion vitreum vitreum Wal leye	0	0	2	0	0	0
Cottidae:						
Cottus asper Prickly sculpin	1	1	0	0	2	0

Table G-2. Summary of incidental catch during the commercial longline fishery.

Family, species, and common name	Marina		
	Arlington	Irrigon	Umatilla
Petromyzontidae:			
<i>Entosphenus tridentatus</i> Pacific lamprey	0	0	0
Acipenseridae:			
<i>Acipenser transmontanus</i> White sturgeon	9	96	164
Clupeidae:			
<i>Alosa sapidissima</i> American shad	0	0	6
Salmonidae:			
<i>Oncorhynchus</i> spp. Salmon	0	0	0
Cyprinidae:			
<i>Cyprinus carpio</i> Carp	1	1	1
Catostomidae:			
<i>Catostomus macrocheilus</i> Largescale sucker	0	0	4
<i>Catostomus</i> spp. Suckers	0	3	0
Ictaluridae:			
<i>Ictalurus nebulosus</i> Brown bullhead	1	2	0
<i>Ictalurus punctatus</i> Channel catfish	23	113	46
Gasterosteidae:			
<i>Gasterosteus aculeatus</i> Threespine stickleback	0	0	0
Percopsidae:			
<i>Percopsis transmontanus</i> Sand roller	0	0	0
Centrarchidae:			
<i>Hicropterus dolomieu</i> Smallmouth bass	0	7	1

Table G-2. (Continued)

Family, species, and common name	Marina		
	Arlington	Irrigon	Umatilla
Percidae:			
<i>Perca flavescens</i> Yellow perch	1	0	1
<i>Stizostedion vitreum</i> Walleye	0	0	1
Cottidae:			
<i>Cottus</i> spp. Sculpins	3	1	3

Table G-3. Summary of incidental catch during index sampling.

Family, species, and common name	Gear			
	Bottom gillnet	Surface gillnet	Electrofishing	
			ODFW	USFWS
Petromyzontidae:				
<i>Entosphenus tridentatus</i> Pacific lamprey	0	0	1	3
Acipenseridae:				
<i>Acipenser transmontanus</i> White sturgeon	166	8	98	77
Clupeidae:				
<i>Alosa sapidissima</i> American shad	131	157	9,255	2,257
Salmonidae:				
<i>Oncorhynchus kisutch</i> Coho salmon	0	0	0	0
<i>Oncorhynchus nerka</i> Sockeye salmon	0	0	0	0
<i>Oncorhynchus tshawytscha</i> Chinook salmon	14	4	310	10
<i>Oncorhynchus mykiss</i> Rainbow trout	40	45	168	24
<i>Oncorhynchus</i> spp. Adult salmon	24	14	129	84
Juvenile salmon	1	1	5,783	720
<i>Prosopium williamsoni</i> Mountain whitefish	12	0	11	65
Cyprinidae:				
<i>Acrocheilus alutaceus</i> Chiselmouth	84	85	637	262
<i>Carassius auratus</i> Goldfish	2	0	45	13
<i>Cyprinus carpio</i> Carp	87	17	1,009	682
<i>Hylocheilus caurinus</i> Peamouth	99	135	432	311
<i>Richardsonius balteatus</i> Redside shiner	0	0	4	0
<i>Rhinichthys cataractae</i> Longnose dace	0	0	0	0
<i>Rhinichthys osculus</i> Speckled dace	0	0	0	0

Table G-3. (Continued)

Family, species, and common name	Gear			
	Bottom gillnet	Surface gillnet	Electrofishing	
			ODFW	USFWS
Catostomidae:				
<i>Catostomus columbianus</i> Bridgelip sucker	134	56	1,182	76
<i>Catostomus macrocheilus</i> Largescale sucker.	1,088	366	8,399	2,372
<i>Catostomus</i> spp. Suckers	0	0	211	6,119
Ictaluridae:				
<i>Ictalurus nebulosus</i> Brown bullhead	8	2	2	5
<i>Ictalurus punctatus</i> Channel catfish	143	43	13	16
Gasterosteidae:				
<i>Gasterosteus aculeatus</i> Threespine stickleback	0	0	0	0
Percopsidae:				
<i>Percopsis transmontanus</i> Sand roller	0	0	2	0
Centrarchidae:				
<i>Lepomis gibbosus</i> Pumpkinseed	0	0	1	0
<i>Lepomis macrochirus</i> Bluegill	0	0	5	0
<i>Pomoxis annularis</i> White Crappie	1	1	1	0
<i>Pomoxis nigromaculatus</i> Black Crappie	3	1	3	1
<i>Pomoxis</i> spp. Crappie	0	0	25	0
<i>Hicropterus dolomieu</i> Smallmouth bass	97	18	952	163
<i>Hicropterus salmoides</i> Largemouth bass	0	0	9	6
Percidae:				
<i>Perca flavescens</i> Yellow perch	12	0	139	8
<i>Stizostedion vitreum vitreum</i> Walleye.	31	4	33	15

Table G-3. (Continued)

Family, species, and common name	Gear			
	Bottom gillnet	Surface gillnet	Electrofishing	
			ODFW	USFWS
Cottidae:				
<i>Cottus asper</i>				
Prickly sculpin	1	0	1	0
<i>Cottus</i> spp.				
Sculpins	0	0	458	0

REPORT B

Economic, Social, and Legal Feasibility of Commercial, Sport and Bounty Fisheries on Northern Squawfish

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ABSTRACT

We report on our research conducted from 1 April 1990 through 31 March 1991 to analyze economic, social and legal feasibility of commercial, sport and bounty fisheries on northern squawfish (*Ptychocheilus oregonensis*). Northern squawfish were provided to this project from three sources: the commercial **longline** fishery, the **sport-reward** fishery, and the dam angling fishery. Samples of northern **squawfish** were provided to the Oregon Department of Environmental Quality for dioxin testing. Dioxin test results are not yet in.

We continued contacts with **several** fish producers to pursue a range of alternative end uses for northern squawfish. These included restaurants, retail markets, bait, organic fertilizer, and fish meal. Northern squawfish were available for utilization testing **from** April 30, 1990 until August 30, 1990. During this time we tested four end uses: bait, organic fertilizer, fish meal, and restaurants. The restaurant and market trials were conducted with minced frozen deboned northern squawfish in Asian businesses in the Portland area and in Salem. Northern squawfish were also used as crab bait, processed as organic liquid fertilizer, and tested in a fish meal processing line.

We developed an extensive collection, transportation, storage and delivery system for northern **squawfish** landed by the commercial longline, sport-reward, and dam angling fisheries.

We completed an initial assessment of regulatory factors important to the development of a full-scale commercial, sport-reward, or dam angling fishery on northern squawfish.

We compared the three major removal methods used in 1990 on the basis of monitoring costs, cost per unit effort, cost per fish removed, and cost per solt saved.

INTRODUCTION

The 1990 season continued our research of the feasibility of alternative fisheries for northern squawfish (*Ptychocheilus oregonensis*) first begun in February 1989. This report summarizes our research activities and results during the first six months of the 1990 project, until 30 September 1990. Our 1990 project has five objectives related to the continued evaluation of the economic feasibility of commercial and bounty fisheries on northern squawfish. These five objectives involved eight activity areas:

1. Conducting tests for dioxin contamination of northern squawfish.
2. Monitoring and evaluation of the commercial **longline** fishery.
3. Monitoring and evaluation of the sport-reward fishery.
4. Monitoring and evaluation of the dam angling fishery.
5. Evaluation of market potential, including collection and transportation.
6. Evaluation of tribal fishery development potential.
7. Evaluation of the legal feasibility of fishery development.
8. Evaluation of the economic performance of the 1990 **test** fishery.

METHODS

Sampling

This project involved sampling at both harvest and market sites. Harvest sites included five **mainstem** dams and the John Day Reservoir of the Columbia River. Populations of northern squawfish were sampled by three different types of fisheries: commercial **longline** (three sites in the John Day Reservoir), sport-reward (four sites in the John Day Reservoir), and dam angling (five **mainstem** dams). For details on the operations of these three fisheries, see Vigg and Burley (this volume).

Northern squawfish were sampled by the three fisheries and provided to the Feasibility Project during different time periods. The dam angling fishery was

conducted between 30 April **and 30** August. The sport-reward fishery operated **between 24** May and 3 September. The commercial **longline** fishery ran between 11 June and 3 August.

We continued to sample Asian restaurant and market sites in Portland and **Salem** as potential avenues of utilization. On the basis of test market information acquired during the 1989 test fishery, we tested northern squawfish in a new product form for human consumption: minced deboned frozen, packed in 600 gram containers. Following the procedure established in 1989, we requested that businesses receiving deliveries of northern squawfish provide us with information on handling costs, selling price, customer response and any other relevant marketing factors.

A total of four markets and restaurants received deliveries of the frozen deboned product. We conducted follow-up interviews with each participating business in early 1991, after a two-month trial **of the** new squawfish product form. Participating businesses are listed in Table B- 1.

Other market sites were chosen on the basis of the location of processor facilities for other identified end uses. Northern squawfish were provided to a fish buyer in **Dallesport**, WA, to be sold as crab bait. A single delivery was made to **Bioproducts**, Inc. in Warrenton, OR, to test northern squawfish as a component of fish meal processing. Several deliveries of frozen fish accumulated throughout the fishing season were made to Inland Pacific Fisheries, Ontario, OR, for trial in a liquid organic fertilizer processing line.

Contaminant Tests

Before the utilization of northern squawfish as a food fish is fully developed, concerns about the safety of human consumption of this fish must be addressed. During the 1989 test fishery we arranged with the Oregon Department of Environmental Quality (**DEQ**) Division of Water Quality Planning to test northern squawfish tissue and organs for pesticides (**PCB's**, chlordane, DDT derivatives) and heavy metals (mercury, aluminum, lead, arsenic). The DEQ does not have testing capability for dioxins, but is able to arrange dioxin tests with private laboratories. Accordingly, the 1990 project included a budget for dioxin tests to be performed on samples of northern squawfish.

Samples of northern squawfish were taken from eleven Columbia River sites during the summer and fall of 1990. Sample sites are listed in Table B-2. Sediment samples were taken from the same locations. Samples were taken from

Table B-1. Restaurants and Retail Markets Testing Frozen Deboned **Minced** Northern **Squawfish** Product, 1990.

Business	Business Category
A Dong Market Salem	Market and Restaurant
Golden Asia Supermarket Portland	Market
Tuck Lung Portland	Market and Restaurant
Yen Ha Restaurant Beaverton.	Restaurant.

Table B-2. Sediment and Tissue Sampling Station Locations for Northern **Squawfish** Dioxin Contaminant Tests, 1990.

Station Number	Location
CR1	Columbia R. at Tenasillahe Island
CR 2	Columbia R. downstream of Longview
CR 3	Columbia R. downstream of St. Helens
CR 4	Columbia R. from Hayden Is. to Rocky Is.
CR 5	Columbia R. from The Dalles to Rocky Is.
CR6	Columbia R. from Browns Is. to Miller Is.
CR 7	Columbia R. near mouth of John Day R.
CR8	Columbia R. from McCormack Slough to Whitcomb Plats
CR9	Columbia R. from Wallula to McNary Dam
WR 1	Willamette R. at SP & S Bridge
CS 1	Columbia Slough near mouth of North Slough

Source: **Oregon Department** of Environmental **Quality** 1990

depositional areas downstream of point and **nonpoint** sources of toxins (Department of Environmental Quality 1990). Each sample consisted of five individuals, weighing **from** 1-3 pounds each. The test design was specified to include analysis of edible flesh (steaks) for all northern squawfish in the samples, and whole body analysis for selected northern squawfish within the samples.

Commercial Fishery

We developed a commercial fishery trip survey form in coordination with the ODFW and UW projects (Vigg et al. 1991; Mathews and Iverson 1991) to collect data on costs of commercial **longline** fishing from the three tribal fishermen participating in the fishery. The survey form is presented in Appendix B-1.1. The survey focused on costs of fishing and was filled in for each fishing trip by **on-board observers**. In addition, we conducted interviews of the three commercial fishermen in coordination with **UW's** Harvest Technology Project. Interviews were conducted at the end of the fishing season to identify problems with fishery administration and implementation. **Fishermen** were also asked their opinions regarding desired changes in fishery operation, safety factors, and market development opportunities. The exit interview survey form is presented in Appendix B- 1.2.

Sport-Reward Fishery

We developed a survey instrument (Appendix B-2) to collect data from the sport-reward fishery on time spent fishing, fishing method, gear used, catch, incidental catch, residence, distance travelled to fish, fishing experience, expenditures associated with fishing, experience with northern squawfish, and opinions about the northern squawfish sport-reward fishery. The sport-reward fishery survey form is presented in Appendix B-2. The survey was administered to every participant in the sport-reward fishery bringing **squawfish** to the landing site. The payment voucher certifying number of northern squawfish caught was incorporated into the **survey** form to ensure a high level of survey response. Receipt of payment for landed squawfish was dependent on the completion of the survey form. The design of the survey instrument was coordinated with the ODFW project, and included several questions on fishing techniques.

We were also interested in the creel clerks' perspective on fishery operations and suggestions for improvement. At the end of the fishing season, the creel clerk supervisor was asked to summarize any problems encountered and to identify any areas of needed change in the administration of the sport-reward fishery.

A derby for northern squawfish held in Vantage, Washington in July 1990 provided an opportunity to observe operation of this type of fishery. We attended the derby, interviewed derby organizers, interviewed derby participants, and weighed and measured catch.

Dam Angling Fishery

A survey instrument was developed by the ODFW project which incorporated all data requirements for the feasibility analysis. The major question of interest to the feasibility project concerning the dam angling removal method is the effectiveness (in terms of northern squawfish removals) per unit cost. Cost effectiveness of the dam angling fishery is compared to the cost effectiveness of the two other major removal methods: commercial longlining and recreational angling. Data elements required for the feasibility analysis are fishing effectiveness expressed in catch per unit effort, incidental catch, gear, bait, time spent fishing, labor costs, and equipment costs.

Market Potential

Limited supplies of northern squawfish during the first (1989) fishing season constrained our tests of end uses of northern squawfish to small deliveries for food, bait, and a sample for a test run of liquid fertilizer processing. Some utilization tests were left undone at the end of the 1989 fishing season. During 1990 we pursued remaining untested uses which had been previously **identified**. These included deboned minced squawfish for restaurant and market trials, full-scale liquid fertilizer processing, fish meal, and crab bait.

Deboned minced squawfish: Exit interviews with participating restaurants and markets at the end of the 1989 fishing season identified the large number of small **bones** in northern squawfish as a major marketing problem. The taste and texture of northern squawfish flesh received good consumer acceptance. Participants indicated that a deboned squawfish product would be more acceptable for human consumption (**Hanna** 1990).

On this recommendation, we arranged with the Oregon State University Seafood Laboratory in Astoria to produce a prototype deboned minced squawfish product. We delivered 132 kgs. of fresh-iced northern squawfish to the Seafood Lab on **23** August 1990. Squawfish was planked, deboned, and packed into 600 gm. containers. **Fifty-nine** containers of the product were then frozen.

We delivered the frozen minced **deboned** product to the four restaurants and markets identified in Table B-1. on 7 November 1990. We conducted **follow-up** interviews with these businesses in early 1991 to determine their evaluation of the new product form. The survey form used in these interviews is presented in Appendix B-3.1.

Liquid fertilizer: Three deliveries totaling 7507 kgs. were delivered to Inland Pacific Fisheries Inc., Payette, Idaho, for liquid fertilizer processing. Data were collected on operating costs incurred during these processing runs. Data were also collected on estimates of market prices for both raw and finished product. The survey form used to collect these data is presented in Appendix B-3.2.

Fish meal: A single delivery of 910 kgs. was delivered to **Bioproducts, Inc.** for a test run in fish meal processing. Data were collected on the results of this trial using the form presented in Appendix B-3.2.

Bait: We delivered 227 kgs. of **squawfish** to Roy Giiore, a bait dealer in Dallesport, Washington, for testing as crab bait. We collected data on the success of northern squawfish as crab bait, as well as on estimated volumes and prices of northern squawfish in this use. The form used to collect these data is presented in Appendix B-3.3.

To provide northern squawfish to the identified end uses, an extensive collection, storage, transportation and delivery system was established at the beginning of the fishing season. Implementation of this system required the purchase of freezers and totes for storage and transportation, arrangement of large volume cold storage holding space, vehicle rental for fish transportation, the arrangement of fish pickups at dams and sport-reward fishing sites, and the coordination of fish storage and deliveries to end users. The system developed to accomplish these tasks is described in detail in Appendix B-7.

Tribal Fishery Potential

The assessment of **tribal** fishery potential began with a synthesis of information on fish processing techniques and an assessment of their adaptability to small-scale operations. The focus has remained on **small-scale** processing technologies for two reasons: 1) interest in the potential for processing of squawfish at scattered locations along the entire Columbia River system; 2) uncertainty about sustainable yield levels expected **from** northern squawfish. Published literature has been searched for descriptions of fish processing methods which might have

application to northern squawfish. Equipment manufacturers were contacted for purchase and operating information.

Contacts were made with personnel in the Market Development arm of the Columbia River Inter-Tribal Fisheries Commission (**CRITFC**) in Portland. Arrangements were made to meet with **CRITFC** and other interested tribal representatives to discuss processing potential and interest in northern squawfish processing projects.

Contact was also made with the Fisheries and Wildlife Division of the Nez **Perce** tribe to discuss their interest in tests of prototype small-scale surimi processing equipment with northern squawfish. The tribe has rights of access to this equipment, produced in Canada. We offered to provide the tribe with northern squawfish for test runs when they were ready to test the equipment.

At the end of the 1990 fishing season, we asked the three tribal fishermen participating in the 1990 **longline** fishery questions related to the potential for developing a tribal commercial fishery on northern squawfish. These questions are identified in Appendix B-1.2 and summarized in the "Commercial **Fishery**" sections (Results and Discussion) and in Mathews and Iverson 1991.

Legal Feasibility

The development of a **full scale** fishery for northern squawfish will require the identification of a full range of regulatory concerns by agencies and tribes. In addition, information needed to complete an Environmental Assessment (**EA**) was required by the Coordination and Review Division of the Bonneville Power Administration (**BPA**). As the **first** step in this process, an extensive list of questions pertaining to the implementation of commercial, sport-reward, and dam angling fisheries was developed by both ODFW and this project and put in questionnaire form (Appendix B-4). The questionnaire was first reviewed within the Oregon Department of **Fish and Wildlife**. The questionnaire was then revised and mailed to state fishery agencies, Columbia River Intertribal **Fish** Commission, the public utility districts, the U.S. Army Corps of Engineers, FPAC members, and **CBFWA** m e m b e r s .

Economic Performance

The three test fisheries-commercial, sport-reward, and dam angling-were evaluated on the basis of their respective economic performance. This evaluation included the adequacy of economic incentives for participation, the direct and indirect costs of the three fisheries, and ~~the cost-effectiveness~~ of each fishery in terms of cost per fish removed, cost per unit effort, and ~~cost~~ per smolt saved. The monitoring systems established for each of the three types of fisheries were evaluated for both organizational effectiveness and cost effectiveness.

RESULTS

Contaminant Tests

Results of tests for dioxin accumulation in the flesh and organs of northern squawfish are not yet available. Samples were sent to the Environmental Protection Agency Lab in Duluth, Minnesota in fall 1990. Several delays in analysis have resulted in revisions of the date for ~~delivery~~ of results. The current estimated delivery date is late July 1991. Results will be summarized in Appendix B-5.

Commercial Fishery

The commercial **longline** fishery was conducted by three tribal fishermen selected and outfitted by the UW project (Mathews and Iverson 1991). The fishery was operated as a subsidized "reward" fishery, with fishermen fishing under contract receiving both a fixed monthly salary and a per-fish payment. A total of 101 fishing trips were made by the three fishermen during the 1990 season. Data on direct operating expenditures by category for the commercial **longline** fishery are summarized in Table B-3. These expenditures include both project-funded purchases and purchases made by the fishermen.

Ice was used on all trips to maintain fish quality. Ice expenditures occur for only 47 trips; jugs of ice **frozen** at home were used for the remaining trips. Bait expenditures represent purchases of salmon **smolts** made by the UW Harvest Technology project and provided to fishermen. A total of 31,842 baits were used. Approximately two-thirds of the bait used was donated to the project. Donated bait incurred some processing, packaging, and collection costs, estimated at \$0.02 per fish. Approximately one-third of the bait used was purchased at a cost of \$0.07 (\$0.05 plus \$0.02 handling) per fish.

Table B-3. Direct Expenditures by **Category** in the Commercial **Longline** Test Fishery for Northern **Squawfish**, 1990.

Expenditure Item	Average Expenditure per Trip (all trips)	Total Expenditure for 1990 Season	Number of Trips for Which Expenditure Recorded
Fuel	\$12.14	\$1,226.24	69
Oil	.67	61.35	26
Engine Maintenance	.08	8.00	1
B a i t	11.51	1,162.23	101
Ice	1.12	113.34	47
Food and Supplies	5.81	587.28	39
Gear and Boat Outfit	74.25	7,500.00	101
Fishermen Salary	136.63	13,800.00	101
Biological Monitor Salary	74.38	7,512.00	101
Payment for Squawfish	56.23	5,680.00	101
Total	\$372.82	\$37,650.44	

Estimates of average expenditures for each category are calculated on the basis' of the total number of trips during the 1990 season, 101. **The** number of **trips** on which the expenditure actually occurred **is** listed in the right hand **column**.

Gear and boat outfitting expenditures **were** made by the University of Washington project at a total of \$2,500 per boat. Expenditure categories included in this total are itemized in Appendix 4, Mathews and Iverson 1991.

Fishermen were paid a fixed salary at a rate of \$2300 per month. Project observers on board each commercial fishing boat were paid a salary of \$1252 per month. Payments for fish landed were made at a rate of \$4.00 per fish. The **total** number of fish caught in the **longline** fishery over the 1990 season was 1420, resulting in a total expenditure for fish payments of \$5,680.

Total and average direct expenditures related to the operation of the commercial **longline** fishery are presented in **Table B-4**. Direct expenditures for the commercial **longline** fishery totaled **\$37,650.44** for the 1990 season. This total includes expenditures made by the research project (here called agency expenditures) in support of the fishery as well as expenditures made by fishermen to cover some of the variable costs of fishing. The total amount of agency expenditures is **also** identified in Table B-4.

For the 101 fishing trips, agency and fishermen expenditures averaged \$372.78 per trip. Total catch for the fishing season was 1420 northern squawfish, resulting in an average direct expenditure of \$26.51 per fish removed. Direct expenditures made by fishermen for fuel, ice, food and other supplies provide both direct and indirect contributions to the local economy.

Indirect expenditures were also made to set up and maintain the operation of the commercial **longline** fishery. The most important of these were the time required of UW project personnel to equip fishermen at the start of the season and the time involved in consultation with fishermen and gear repair throughout the season. Due to the difficulty of assigning a fixed amount of time to these activities, these costs are acknowledged but unquantified.

Costs and returns to the three fishermen participating in the test fishery are summarized in Table B-5. Returns to fishermen, gross revenues, are comprised of monthly salaries and payment for each fish landed. Total gross revenues to the three fishermen for the 1990 season were \$19,480.

Costs to fishermen included expenditures for fuel, oil, engine maintenance, ice and food. These costs vary with the level of fishing effort. Bait and gear would normally be included in the calculation of variable costs to fishermen, but because both were provided to fishermen free of charge by the University of Washington Gear Technology Project (Mathews and Iverson 1991) they were not included as costs to fishermen.

Table B-4. Total and **Average** Direct **Expenditures** in the Commercial **Longline** Test Fishery for Northern **Squawfish**, 1990.

Expenditure Type	Amount
Total Direct Expenditures (Agency Plus Fishermen)	\$37,650.44
Average Direct Expenditure per Fishing Trip (Agency plus Fishermen)	\$372.78
Average Direct Expenditure per Fish Removed . (Agency plus Fishermen)	\$26.5 1
Total Direct Expenditures Agency Only (fisherman salary, biological monitor salary, gear and boat outfit, bait, payment for squawfish)	\$35,654.00
Average Agency Expenditure per Fishing Trip	\$353.01
Average Agency Expenditure per Fish Removed	\$25.11

Table B-5. Costs and Returns to **Fishermen** in the Commercial **Longline** Test Fishery for **Northern Squawfish**, 1990.

Costs and Returns	Amount
Total Gross Revenues to Fishermen (salary, payment for squawfish)	\$19,480.00
Total Variable Costs to Fishermen (fuel, oil, maintenance, ice, food)	\$1,996.21
Total Net Revenues to Fishermen (Total Revenues - Total Variable Costs)	\$17,483.79
Average Gross Revenues per Trip	\$ 1 9 2 . 8 7
Average Variable Costs per Trip	\$19.76
Average Net Revenues per Trip	\$173.11
<u>For the Total 1990 Fishing Season:</u>	
Average Gross Revenues per Fisherman	\$6,493.33
Average Variable Costs per Fisherman	\$665.40
Average Net Revenues per Fisherman	\$5,827.93

Fishermen also incurred fixed costs such as insurance payments, loan payments, and depreciation of their boats. **Because** of the difficulty of separating the proportion of fixed costs due to northern squawfish fishing from the proportion due to other fishing activities, fixed costs were not included in the calculation of net returns to fishermen in the longline fishery.

Net revenues to fishermen are calculated by subtracting total variable costs from total revenues. Net revenues calculated in this way provide an approximation of **profit**, or operating margin. It is only an approximation because to precisely calculate profit, fixed costs would need to be included in the calculation. Also included should be a value assigned to the fisherman's time. This value is called "opportunity cost" and represents the amount of money he could earn in an alternative activity if he were not fishing. The net revenues exhibited in Table B-5 are therefore an overestimate of profits to fishermen.

Total net revenues to the three **fishermen** participating in the 1990 test fishery were **\$17,483.79**. This is a net revenue per trip of \$173.11, Net Revenues per fisherman for the 1990 season were **\$5,827.93**.

As noted above, bait and gear were provided free of charge to the fishermen participating in the test fishery. If fishermen had been required to purchase their own bait, net revenues per trip would have been \$161.60. If fishermen had been required to purchase the gear and boat outfit, net revenues per trip would have been \$87.35. If we assume a value of a fisherman's time at \$10 per hour, and assume further an 8 hour fishing day and one day per trip, this level of net revenues is close to the break-even point where returns are just covering costs. Adding an amount for tied costs might result in this level of financial return falling below the break-even level. On a per fisherman basis, assigning gear and bait costs to fishermen would have resulted in net revenues per fisherman for the season of **\$2,940.52**, approximately 50% less than actual net revenues.

Exit interviews were conducted with the three commercial fishermen in August and October 1990. The exit interview form is presented in Appendix B-1.2. During these interviews questions were asked regarding impressions of the northern **squawfish** commercial fishery operation, other fishing activities routinely engaged in, market potential for squawfish, and improvements in fishery conduct. Characteristics of participating commercial fishermen and their operations are summarized in Table B-6.

In general, the three fishermen saw little market potential for squawfish. Commercial fishery potential was judged to be limited to a subsidized "bounty" fishery. Subsidization was deemed necessary because of the lack of an established

Table B-6. Summary Characteristics and Opinions of Commercial **Longline** Fishermen,
Northern Squawfish Test Fishery 1990.

Fishing Experience	3-21 years
Boat Ownership	2 owner-operated 1 hired crew
Major Fisheries	salmon steelhead sturgeon
Marketing Arrangements	Fish buyer direct sales

market, the requirement to invest in new gear, and low expected catch rates. Fishermen preferences for a commercial fishery operating plan were to open it to any qualified **tribal** fisherman and regulate by seasons and gear.

Regarding tribal consumption of northern **squawfish**, fishermen reported **some** knowledge of pressure cooked squawfish being consumed at home. Further detail on the **longline** fishery interviews is found in Mathews and Iverson 1991.

Sport-Reward Fishery

The sport-reward fishery was conducted between 24 May to 3 September, 1990. A total of 2,376 anglers participated in the fishery. Of these, 505 registered their catch and completed questionnaires. Some questionnaires include information for **all** members in the fishing party, e.g. age, so total numbers of responses to some questions may be larger than the number of questionnaires. Details on sport-reward fishery catch and operation are summarized in Vigg et al. 1991. The form developed to collect data on the sport-reward fishery is included in Appendix B-2. The results of the angler survey are summarized below.

The sport-reward fishery involved direct agency expenditures for creel clerk wages, reward payments, uniforms, **vehicles**, fuel, oil, and **miscellaneous** equipment. These costs are summarized in Table B-7. A total of \$44,376 was spent by the ODFW to set up and operate the sport-reward fishery. Also involved were **indirect** expenditures of agency personnel time involved in fishery design, establishment of the **monitoring** system, processing of vouchers, and oversight of fishery operations.

The sport-reward fishery was divided into two subseasons. The first subseason extended from 24 May until 19 July and paid a reward of \$1 for each delivered northern **squawfish** over 11" in length. The fishery included four marina registration sites at Plymouth, **Umatilla**, **Arlington**, and Le Page Park. The second subseason extended **from** 19 July until 3 September with a reward of \$3 per squawfish over 11". During the second subseason the registration site at Arlington was eliminated, leaving three registration sites with expanded operating hours. The reasons for these changes between the first and second subseason are detailed in Vigg et al. 1991. Because of the different conditions under which the two subseasons were operated, survey results are summarized for each subseason. Subseason 1 (\$1 reward per fish), hereafter called Season 1, is represented by 118 questionnaires; subseason 2 (\$3 reward per squawfish), hereafter called Season 2, is represented by 387 questionnaires.

Table B-7. Direct Agency Season Expenditures for Sport-Reward Fishery Operation, 1990. _

Expenditure Category	Amount
Creel Clerk Wages	\$20,058
Reward Payments	12,518
Vehicles	7,200
Fuel, Oil	2,400
uniforms	200
Misc. Equipment	2,000
Total	\$44,376

The questionnaires were designed to **provide answers** to **several** questions. Angler survey- results are summarized in **Tables B-8.- B-14.**

Who went fishing? Ages of **fishermen** ranged from 14 to over 70. During Season 1 fishermen were concentrated in the 31-50 age range: 53% of the fishermen fell into this age bracket. Twenty-eight percent of the fishermen were aged from **14-30**, and 19% **were over 50**. Fishermen in Season 2 were more evenly distributed by age, with 47% falling into the 31-50 age bracket, 24% in the **14-30** bracket, and 29% in the 51 and up bracket.

Both seasons attracted a high percentage of anglers who fish several times a year. Sixty-two percent of the Season 1 fishermen and 63% of the Season 2 fishermen normally fish over 25 trips-per year. The contrast between Season 1 and Season 2 lies primarily in the slightly higher percentage of fishermen who normally fish fewer than 11 trips per year in Season 2 (20%) as opposed to Season 1 (15%).

The largest proportion of anglers fishing in both seasons were accustomed to fishing in the John Day pool; 58% of the fishermen in Season 1 had fished the reservoir for over 5 years, as had 50% in Season 2. Season 2 attracted, a larger percentage of anglers with less experience fishing in that reservoir: 30% had fished in the reservoir under 1 year, in contrast to 19% in Season 1.

How far did fishermen travel to fish northern squawfish? In Season 1, 43% of participating anglers **travelled** less than 20 miles to fish for northern squawfish, but 22% travelled over **100** miles. Season 2 attracted a higher proportion of anglers **from** both in area and out of area; 39% **travelled** under 20 miles, and the number **travelling** over 100 miles increased to 30%.

How much time did fishermen spend fishing for northern squawfish? A total of 589.05 angler hours were spent fishing for northern squawfish during Season 1. Time spent fishing increased to **2,608.6** angler hours during Season 2. This translated to an average fishing time of 4.99 hrs. per trip in Season 1 and 6.74 hrs. in Season 2. **Time** spent fishing and other summary information about the characteristics of fishing trips are presented in Table B-9.

How did fishermen fish for northern squawfish? Fishermen fished in parties of just over 2 people on average in both Season 1 and Season 2. Total numbers of people fishing in parties of anglers who **filled** out questionnaires were **255** in Season 1, and 781 in Season 2.

Anglers used several methods to fish for northern squawfish (Table B-10). An average of 1.46 methods were reported per trip in Season 1; an average of 1.57

Table B-8. Sport-Reward Fishery Angler Characteristics, 1990.

	Season 1 \$1 reward # (%)		Season 2 \$3 reward # (%)	
<hr/>				
Age				
14-20	20	(14)	35	(08)
21-30	20	(14)	72	(16)
31-40	33	(23)	104	(24)
41-50	42	(30)	101	(23)
51-60	22	(16)	69	(16)
61-70	4	(3)	50	(11)
>70	0	(0)	8	(2)
Number of Fishing Trips per Year				
0	6	(5)	4	(1)
1-5	7	(6)	41	(11)
6-10	5	(4)	31	(8)
11-15	11	(10)	22	(6)
16-20	14	(12)	25	(7)
21-25	5	(4)	13	(4)
>25	70	(62)	232	(63)
Years Fishing John Day Reservoir				
<1	21	(19)	109	(30)
1-3	16	(14)	40	(11)
4-5	10	(9)	34	(9)
>5	66	(58)	182	(50)
Miles traveled to Fish				
<20	49	(43)	141	(39)
20-39	23	(20)	64	(18)
40-59	10	(9)	25	(7)
60-79	8	(7)	16	(4)
80-99	2	(2)	9	(2)
>100	22	(19)	109	(30)

Table B-9. Fishing Trip Characteristics, Sport-Reward Fishery 1990

	Season 1 \$1 Reward	Season 2 \$ 3 R e w a r d
Average Length of Trip (hrs.)	4.99 hrs.	6.74 hrs.
Average No. of Squawfish Caught per Trip	459	103
Maximum No. of Squawfish Caught in a Single Trip	42	127
Average Reward per Trip	\$4.59	\$30.94
Average Number in Fishing Party	2.16	2.02
Average Number of Fishing Methods Used per Trip	1.46	1.57
Average Number of Incidental Catch per Trip (all species)	5.79	4.34

Table B-10. Frequency of **Fishing Methods** Used in the **Sport-Reward Fishery by Season**, 1990.

	Season 1 \$1 Reward # (%)	season 2 \$3 Reward # (%)
<u>Fishing Method</u>		
Boat, anchored	16 (9)	41 (7)
Boat, drifting	24 (14)	80 (13)
Boat, trolling	29 (17)	109 (18)
Shore	49 (28)	191 (31)
Angling, surface	12 (7)	59 (10)
Angling, bottom	34 (20)	116 (19)
Other	8 (5)	12 (2)
Ave. # Methods Used per Trip	1.46	157

methods were reported per trip in Season 2. -In Season 1, the most common method reported was fishing **from** the shore, followed by angling on the bottom, trolling, drifting, anchored, angling on the surface, and “other”.

In Season 2, almost the same pattern of fishing methods held. Again, the most common fishing method was fishing **from** shore, followed by angling on the bottom, trolling, drifting, angling on the surface, anchored, and “other” .

Table **B-11** looks at fishing methods used by anglers in relation to their fishing success for both seasons combined. Angling methods are ranked in each of three groups: 1) methods used for **all** fishing trips landing any northern squawfish; 2) methods used in fishing trips landing 9 or more northern squawfish; 3) methods used in fishing trips **landing** 20 or more northern **squawfish**. The most popular method used at all levels of success was fishing from shore, comprising from 30-48% of all methods tried, followed by angling from the bottom. For landings of 9 and above and 20 and above, the third most common method was angling from the surface, whereas for the lower catches the third most common method used was **trolling**.

A variety of bait and tackle were used to catch northern squawfish. Table **B-12** lists frequency of bait and tackle used in each season. An average of 1.89 types of bait or tackle were used **per** trip in Season 1; this increased to an average of 2.17 per trip in Season 2. In Season 1 the most common was worms, followed by spinners, hook and line with 1 hook, “other”, spoons, hook and line with more than 1 hook, surface plugs, flatfish, and cut fish bait.

The most common type of bait or tackle used in Season 2 was again worms, followed by spinners, spoons, hook and line with 1 hook, “other”, flatfish, hook and line with more than 1 hook, surface plugs, and cut fish bait.

Table **B-13** lists bait and tackle used by anglers in relation to their fishing success in both seasons combined. Bait and tackle are ranked in each of three groups: 1) those used for all fishing trips landing any northern **squawfish**; 2) those used in fishing trips landing 9 or more northern **squawfish**; 3) those used in fishing trips landing 20 or more northern squawfish. Different levels of fishing success are associated with different bait and tackle used. The most common method for trips landing any amount of northern squawfish was worms, followed by spinners; for trips landing 9 or more and 20 or more northern squawfish the most common was spoons, followed by worms.

The average purchase price reported for the bait and tackle used to fish for northern squawfish was \$11.26 in Season 1, increasing to \$13.91 in Season 2.

Table B-11. Frequency of **Fishing** Methods Used in the Sport-Reward Fishery by Fishing success,. 1990.

	Any Fish L a n d e d		≥ 9 Fish Landed		≥ 20 Fish Landed	
	#	(%)	#	(%)	#	(%)
<u>Fishing Method</u>						
Boat, anchored	57	(7)	14	(6)	9	(7)
Boat, drifting	104	(13)	14	(6)	9	(7)
Boat, trolling	138	(18)	7	(3)	6	(5)
Shore	240	(31)	108	(48)	49	(40)
Angling, surface	71	(9)	32	(14)	20	(16)
Angling , bottom	150	(19)	43	(19)	25	(21)
Other	21	(3)	7	(3)	4	(3)

Table B-12. Frequency of Bait and Tackle Used in the Sport-Reward Fishery by Season, 1990.

	Season 1		Season 2	
	\$1 Reward		\$3 Reward	
	#	(%)	#	(%)
<u>Bait or Tackle</u>				
Worms	70	(31)	249	(30)
Cut Fish Bait	3	(1)	28	(3)
Spinners	48	(22)	176	(21)
spoons	19	(9)	115	(14)
Flatfish	6	(3)	46	(55)
surface Plugs	8	(4)	34	(4)
Hook & Line, 1 hook	32	(14)	90	(11)
Hook & Line, >1 hook	16	(7)	35	(4)
Other	21	(9)	65	(8)
Ave. # Bait or Tackle Used per Trip	1.89		2.17	

Table B-13. Frequency of Bait and Tackle Used in the Sport-Reward Fishery by Fishing success; 1990.

	Any Fish Landed # (%)	≥ 9 Fish Landed # (%)	≥ 20 Fish Landed # (%)
<u>Bait or Tackle</u>			
Worms	320 (30)	80 (23)	41' (22)
Cut Fresh Bait	31 (3)	20 (6)	17 (9)
Spinners	224 (21)	60 (17)	35 (19)
spoons	134 (13)	83 (24)	44 (24)
Flaffish	52 (5)	23 (7)	15 (8)
Surface Plugs	42 (4)	11 (3)	6 (3)
Hook & Line, 1 Hook	122 (11)	32 (9)	11 (6)
Hook & Line, >1 Hook	51 (5)	8 (2)	3 (2)
Other	86 (8)	31 (9)	14 (8)

What did anglers catch? Anglers caught a total of 542 northern squawfish in Season 1 and 3,992 in Season 2. Average catch per **trip was 4.59** fish in Season 1, increasing to 10.3 per trip in Season 2. The maximum number of northern squawfish caught in a single trip increased to 127 in Season 2 as compared to 42 in Season 1 (Table B-9).

An average of **.8** undersized northern squawfish per trip **were thrown** back in Season 1, decreasing slightly to an average of **.71** northern squawfish per trip thrown back in Season 2.

Anglers reported small amounts of incidental catch of several species. Incidental catch was reported of the following species: walleye, sturgeon, **smallmouth** bass, **catfish**, salmon, steelhead, shad, carp, sucker, and "other". Average number of incidental catch by species by trip for both seasons is listed in Table B-14. In both fishing seasons, smallmouth bass had the highest levels of incidental catch. In Season 1, the species with the second highest level of incidental catch was suckers. In Season 2, the species with the second highest rate of incidental catch was walleye.

What was the previous angler experience with northern squawfish? Angler experience either catching or eating northern squawfish is **summarized** in Table B-15. Approximately the same percentage of fishermen in each season had fished for northern squawfish before: 58% in Season 1 and 56% in Season 2.

Anglers were asked if they had ever caught northern squawfish while fishing for another species. In Season 1, **77%** of anglers indicated they had caught northern squawfish often, and others indicated that they had caught northern squawfish occasionally while fishing for other species. In Season 2, the percentage which had often caught northern **squawfish** fell to 69% and the proportion which had caught them only occasionally increased.

We asked those who had previously caught northern squawfish to tell us what they had done with the fish. The patterns are almost the same in both seasons. The most common method of disposition of northern squawfish was to throw them away. This was followed by releasing them back to the river, "other", used as fertilizer, fed to animals, given away as food for others, and eaten by themselves.

A minority of fishermen in both seasons had ever eaten squawfish. Seventeen percent in the first season and 7% in the second season said they had eaten squawfish before. Of these, 71% rated it unsatisfactory as a food fish in Season 1, as compared to 46% rating it unsatisfactory as a food fish in Season 2.

Table B-14. **Incidental Catch Per Trip by Species and Fishing Season, Sport-Reward Fishery 1990.**

	Season 1 Average # per Trip	Season 2 Average # per Trip
<u>Species</u>		
Walleye	.19	.88
Sturgeon	.23	.15
Smallmouth Bass	2.05	1.74
Catfish	.31	.26
Salmon	0	.15
Steelhead	.01	.16
Shad	.2	.3
Carp	.3	.2
Sucker	1.9	.3
Other	.6	.2
	<hr/>	<hr/>
Total	5.79	4.34

Table B-15. Angler Experience with Northern **Squawfish**, 1990

	Season 1		Season 2	
	#	(%)	#	(%)
Fished for squawfish before?				
Yes	68	(58)	217	(56)
No	50	(42)	170	(44)
Caught squawfish incidentally before?				
Yes, often	91	(77)	267	(69)
Yes, sometimes	20	(17)	102	(26)
No	7	(6)	18	(5)
How dispose of squawfish before?				
Threw away	60	(35)	194	(42)
Released	35	(20)	120	(26)
Fertilizer	21	(12)	30	(7)
Animal feed	19	(11)	33	(7)
Gave away as food	13	(8)	26	(6)
Ate	10	(6)	21	(5)
Other	24	(14)	54	(12)
Eaten squawfish before?				
Yes	20	(17)	28	(7)
No	98	(83)	359	(93)
How rate squawfish as food fish?				
Very Satisfactory	0	(0)	1	(2)
Satisfactory	7	(29)	21	(51)
Unsatisfactory	17	(71)	19	(46)

What was the angler opinion of the northern squawfish fishing experience? Fishermen were asked to rate their experience fishing for northern squawfish. In Season 1, **56%** of those responding said that they were satisfied, 31% said they were indifferent, and 13% said they were not satisfied. The percentage of satisfied fishermen- increased in Season 2: 70% were satisfied, 21% indifferent, and 9% not satisfied.

Season 1 had a higher percentage of fishermen who **said** they planned to fish squawfish again in 1990 (78%) than Season 2 (70%). This difference might be attributed to the shorter remaining fishing time in Season 2 compared to Season 1.

Where did anglers stay and what did they spend while fishing for northern squawfish? The majority of anglers stayed one day or less in the area when fishing for northern squawfish: 69% in Season 1; 59% in Season 2. Season 2 differed from Season 1 in the higher percentage of anglers **that** stayed in the area 2 or more days.

Of those anglers who stayed overnight, the majority in both seasons stayed in motels. The second most common type of accommodation listed in both seasons was a state park, followed by national parks, private campgrounds, friends or relatives, and "other."

Total season expenditures on various services in the **fishing** area are listed in Table B-16. Not **all** anglers made expenditures in the fishing area on **all** trips. Expenditures by anglers in the fishing area constitute contributions to local economic activity and can be considered economic **returns** related to the fishery as are expenditures made by commercial fishermen for bait, fuel, and services.

Two types of calculation are presented in Table B-16. Total expenditures in each category represent **all** expenditures made in each season by anglers. Because of the large increase in the number of anglers in Season 2 as **compared to** Season 1, total expenditures in Season 2 increased to more than 5 times Season 1 expenditures. Also presented in Table B-16 are average expenditures **calculated** over the number of angler days. Angler days are the number of days fished by the total number of anglers in a season. **The** average expenditure per angler day represents the total **amount** spent during a season divided by the total number of angler days. The average amount spent per angler day was \$15.11 in Season 1, increasing slightly to \$17.65 in Season 2. Expenditures per angler day exceeded rewards earned per angler day (\$2.13 in Season 1; \$15.31 in Season 2) in both seasons.

Table B-16. Angler Expenditures Related to Fishing for Northern Squawfish in the Sport-Reward Fishery, 1990.

Expenditure Category	Season 1 Total Expenditure	Season 2 Total Expenditure
Accommodations	\$517.25	\$3211.81
Restaurants	\$ 4 7 1 . 0 0	\$2738.65
Groceries	\$1094.30	\$4543.00
Other Food	\$110.00	\$317.30
Gas	\$857.74	\$4543.70
Fishing Supplies	\$284.50	\$2239.58
Bait	\$93.94	\$614.34
O t h e r	<u>\$61.50</u>	<u>\$223.00</u>
Total	\$3490.23	\$18431.38
Total Number of Angler Days	231	1044
Average Expenditure per Angler Day	\$15.11	\$17.65

Did anglers have any problems at the boat ramps or on the water? A relatively **small** number of problems with either the **boat** ramps or fishing on the **water** were reported: 31 complaints (6%) on 505 surveys.

Five **problems** were cited in connection with the boat ramps. Three complaints concerned overcrowding which led to a slow launch, one concerned a bad ramp bumper, and one indicated the ramp was too **narrow**.

Twenty-six comments concerned problems on the water. These included crowding problems with other sport fishermen and with commercial fishermen, boats passing too fast, jet skis and water skiers passing at high speeds, trash on the banks, and conflicts with commercial fishing gear.

Creel clerk evaluation of sport-reward fishery operations: In addition to surveying anglers, we asked creel clerks employed at the sport-reward fishery registration sites to summarize their experience with the operation of the fishery.

Creel clerks reported the following concerns and suggestions regarding the operation of the sport-reward fishery. Some suggestions were made by participating anglers and passed on to this project through the creel clerks. A summary of these comments was presented to this project by S. Rimbach, creel clerk supervisor.

Angler suggestions: The \$1 reward was not seen as sufficient by anglers to encourage them to target fishing effort on northern squawfish. The \$3 reward was considered sufficient to encourage anglers to target effort on northern squawfish. The sport-reward hours of 6:00 A.M. to 3:00 P.M. were not long enough to encompass either sunrise fishing or after-work fishing. The extension of fishery hours into the evening improved access to the fishery. Suggestions were made to advertise the sport-reward fishery more widely and to provide more detailed information on the location of the check-in stations.

Creel clerk suggestions: The extension of the sport-reward fishery into the evening hours meant that clerks were required to process fish in the neardark. Many anglers returned to the check-in stations during the last 15 minutes of the fishery hours, causing additional difficulties of processing fish in poor light. A portable lighting system would alleviate this problem. Creel clerks also outlined the need for stricter guidelines for the timing of both angler and fish registration. For examples, guidelines would specify to creel clerks whether anglers must be registered before bringing in fish or whether it would be permissible to register and bring in fish simultaneously.

Creel clerks suggested that each check-in station be assigned its own pre-numbered **survey** and data forms to avoid passing them back and forth between stations. The provision of radios to each check-in station would better equip stations for emergency-situations, particularly when creel clerks are stationed alone during evening fishing hours. The need to establish an alternate clerk system for cases of illness or emergencies was also identified. Finally, creel clerks noted that many people saw them as a potential information source for the Department of Fish and Wildlife. An information flyer listing ODFW programs and contact numbers would help clerks answer questions.

At the beginning of the fishing season we **had anticipated** the potential for boat ramp conflicts at sport-reward fishery landing sites. The prospect of a large number of anglers participating in the sport-reward fishery raised the possibility of long waits at boat ramps as well as space conflicts between anglers on the water. Although a few problems were reported by anglers filling out questionnaires (discussed above), none such conflicts were observed by the creel clerks **themselves**.

Conduct of a fishing derby: A complete discussion of the Vantage, Washington fishing derby for northern squawfish is included in Appendix B-6.

Dam Angling Fishery

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The primary analysis of the dam angling fishery data is included in Vigg et al. 1991. The focus of **interest** for the feasibility project in this fishery are fishing effectiveness (CPUE), incidental catch, and costs for gear, bait, and labor and equipment.

As illustrated in Table B-17, dam angling areas varied a great deal in both total catch and catch per unit effort (in number of fish per angler hour). The **all-dam** average CPUE was 1.73 fish per angler hour, ranging from a low of **.19** at Bonneville **#2** station to a high of 3.39 at **McNary**. Differences in CPUE result in corresponding differences in monitoring costs (labor costs) per fish between areas, also illustrated in Table B-17. Because of its very low catch rates, **Bonneville # 2** represented the highest labor cost per fish removed. **McNary** had the lowest labor cost per fish removed.

Total direct agency expenditures in the dam angling fishery are presented in Table B-18. Direct expenditures are **all** expenditures dedicated to the operation of the clam angling fishery. As with the other two fisheries, indirect costs were also incurred, primarily in the form of agency personnel time spent designing, setting up, and overseeing the fishery operation. These expenditures are recognized for all

Table B-17. Catch, Catch per Unit Effort, and Monitoring Costs per Fish in the Dam Angling Fishery, 1990.

Dam	Catch (# fish)	CPUE (Number per angler hour)	Monitoring Cost per Fish*
Bonneville #1	3373	2.5	\$5.94
Bonneville #2	235	.19	\$85.24
The Dalles	1146	1.11	17.48
John Day	1338	1.27	14.97
McNary	4386	3.39	4.57
Ice Harbor	527	1.32	2453
Average	1834.17	1.73	\$24.53

• Monitoring cost per fish includes only the dam angler salary in the calculation. Total direct costs associated with the administration of the dam **angling** fishery are summarized in Table B-18.

Table B-18. Direct Agency Expenditures by Category in the Dam Angling Fishery, 1990.

Expenditure Category	Amount
Angler Wages	\$110,176
Vehicle Rental	20,000
Fuel, oil	4,000
Uniforms, Hard Hats, Life Jackets, etc.	4,275
Rods and Reels	4,474
Misc. Equipment	<u>7,950</u>
Total Direct Expenditures	\$150,875

three fisheries **but** remain unquantified due to the **difficulty** of assigning separate portions of management time to each of the three fisheries.

A total of \$150,875 was spent in direct expenditures on the dam angling fishery in 1990.' The largest expenditure component was angler wages. Table B-19 summarizes total and average direct expenditures in the dam angling fishery. Average expenditures are expressed in both dollars per angler hour (\$23.67) and dollars per fish removed (\$13.71).

The three fisheries are compared on the basis of total costs and of average costs of effort and average costs per fish removed in Tables B-24 and B-25 in the "Economic Performance" section.

Market Potential

The collection, storage, transportation and delivery system proceeded as follows. Northern squawfish collected by the dam angling, sport-reward and **longline** fisheries were put into plastic bags and then into chest freezers located near the removal sites. The bags of **frozen** fish were allowed to accumulate on site until freezers became full. The **frozen** bags were then picked up and pitched into commercial fish totes on a flatbed truck and delivered to one of three **freezer** facilities for temporary storage. Volumes of northern squawfish were retrieved **from** the **freezer** facilities and delivered to various end users on request. A detailed summary of the logistics and costs of the collection and delivery system is presented in Appendix B-7.

As previously indicated, northern **squawfish** was tested in four type of end uses in 1990: deboned minced squawfish, liquid fertilizer, fish meal, and bait.. Preliminary summaries of these tests are provided below.

Deboned minced squawfish: Yield of squawfish was tested during the deboning process. The delivery of 13 1.84 kgs. of round fish yielded 60.54 kgs. of planks (**head**, backbone, tail and viscera removed). **Minced** flesh yield based on round weight was 29.79%. Minced flesh yield based on plank weight was 64.88% (Crawford 1990). Minced deboned fish was packed into 600 gram clear plastic containers and frozen.

Restaurants and markets which received frozen deboned minced northern squawfish indicated a high level of acceptance overall. Taste is evaluated as excellent, texture is good, and the major consumption problem (bones) has been

Table B-19. Total and Average Direct Agency Expenditures in the Dam **Angling Fishery** for Northern Squawfish, 1990.

Expenditure Type	Amount
Total Direct Expenditures	\$150,875.00
Average Direct Expenditure Per Angler Hour	\$23.67
Average Direct Cost Expenditure Per Fish Removed	\$13.71

eliminated. Tables B-20 to B-22 summarize the results of the deboned product evaluation interviews.

In general, all product attributes were deemed acceptable to very good by the majority of users (Table B-20). Users were particularly impressed with the ease of handling and the versatility of the product. Some had suggestions for improving the binding qualities of the minced fish.

For the purpose of future product development planning, we asked some general questions about product attributes important to their business. These are summarized in Table B-21. The most important product attributes **from** these users' points of view are product form, taste, labeling, and name. One restaurant noted that quantity demanded of deboned squawfish would likely be **fairly** sensitive to the price of whitefish fillets, since fillets can substitute for the deboned fish product and are also more versatile. Least important product attributes to these businesses are texture of the flesh and the type of packaging.

We asked users to give us their best estimate of the price they would be willing to pay for deboned minced northern squawfish, the quantities they would buy at this price, and the retail price at which they could sell either the deboned minced fish product or final products made with the deboned minced fish. None of the businesses was able to say what quantities they would be likely to use since they had as yet had so little experience with the product. Estimates of reasonable wholesale and retail price ranges for the deboned minced fish product are presented in Table B-22. The businesses we interviewed would be willing to pay between **\$.75** and **\$1.50** per 600 grams for deboned minced northern squawfish, wholesale. Estimates of reasonable retail prices for the same product ranged between **\$1.99** and **\$2.99** per 600 grams. Processed final products were expected to sell for between **\$3.00** and **\$8.00**, depending on the final form.

Liquid fertilizer: Experiments with northern squawfish in this form consisted of processing 4,773 kgs. of northern **squawfish** into liquid fertilizer using a low temperature enzyme hydrolysate process. Northern squawfish were combined with carp for this process because the oil content of **squawfish** alone is not high enough for this process.

The liquid fertilizer product was sold for fertilizing potatoes and for soil application on wheat stubble. Several hundred pounds of northern squawfish were not usable by this processor due to sand in the bags. The user estimated that the most feasible way to process squawfish in this product line is in large volumes of 10 to 20 tons. Processed in the liquid fertilizer form in large volumes, squawfish could expect to sell exvessel at **\$.05-.10** per pound. Table B-23 summarizes a

Table B-20. Restaurant and Retail Market Evaluation of Product Attributes of Frozen **Deboned** Minced Northern Squawfish Product, Fall 1990.

Product Attributes	Assessment
Quality	Below Average - Good
Appearance	Good
Taste	Below Average - Very Good
Ease of Handling	Very Good
Flesh Color	Average - Good
Package Form	Good - Very Good
Package Size	Good - Very Good
Product Uniformity	Very Good

Table B-21. Participating Restaurants' and Markets' Average Rankings of the Importance of General Product Attributes.

Attribute	Average Ranking*
Price	8.5
Product Form	9.25
Flesh Color	8.9
Flesh Texture	5.0
Taste	9.25
Package Form	6.5
Package Size	8.4
Product Uniformity	8.5
Labeling	9.25
Shelf Life	8.25
Supply Availability	8.0
Product Name	9.0
Ease of Handling	8.5

1 = not important
 10 = very important

Table B-22. Estimates of Potential **Wholesale** and Retail Prices for Frozen Deboned Minced Northern Squawfish Products.

Price Level	Estimated Price per 600 grams
Wholesale Price	\$.75 - \$1.50
Retail Price (unprepared product)	\$1.99 - \$2.99
Retail Price for Final Products	
soup	\$3.00 - \$5.00
Fish Cakes	\$3.00 - \$4.00
Fish Patties	\$7.00 - \$8.00

Table B-23. Estimated Ranges of Values for Major **Operating** Costs, Liquid Fertilizer Processing.

Variable Cost Category	Processing Cost for 2273 Kg.	Cost per Kg. Raw Product
Labor	\$95 - 155	\$.02 -.03
Materials:	\$220 - 280	\$.04 -.06
Cooling	\$35 - 50	\$.01 -.02
Storage	\$20 - 30	\$.01 -.02
shipping) Packaging	\$275 - 325	\$.06 -.07
Total Variable cost:	\$645 - 830	\$.14 - .20

range of costs associated with this type of fish processing, expressed as both total costs and as costs per kg. of raw product processed.

Fish meal: The experiment using northern squawfish in this process was not a success. One trial was run in **which** whole **northern** squawfish **were processed in** a steam dryer to **make** a liquid fish diet. The processor indicated dissatisfaction with northern squawfish in this process, citing an offensive odor as the main problem. The processor evaluated northern squawfish as not suitable in this processing technique. This feedback is not consistent with expectations of other fish meal processors. Further opportunities to test northern squawfish in a fish meal processing line will be pursued in 1991.

Bait: Three hundred northern squawfish weighing a total of 227 kgs. were delivered **frozen** to a bait dealer. The dealer provided the northern squawfish free of charge to crab fishermen to use as bait. Fishermen picked up the northern **squawfish** at the dealers in **frozen** round form; thus no costs were incurred for delivery, preparation or processing. The general conclusion from the bait trials is that of the two uses, crab and crayfish bait (tested in **1989**), northern squawfish is more suitable for crayfish bait. The **crayfish** market, and therefore crayfish fishing, is highly variable, but when the market is active the crayfish might serve as an outlet for about 2,000 lbs. per week, sold at an estimated **\$.10** per pound.

Tribal Fishery Potential

A report on the characteristics of various fish processing techniques is included in Appendix B-8. This report lists **several** fish processing techniques and outlines the operating costs and requirements of each. There are three key attributes of northern squawfish which influence appropriate processing techniques: low **oil** content of flesh, a large number of small bones, and a seasonal production pattern of as yet unknown size and variability. These factors must be included in included in any assessment of the potential applicability of the various processes to northern squawfish. In addition, the selection of an appropriate processing technique will be directed by the nature of the market, as yet undetermined.

The assessment of commercial fishery potential by the three tribal fishermen participating in the 1990 fishery is summarized in the "Commercial Fishery" section as well as in Mathews and Iverson 199 1. From the perspective of the fishermen participating in the 1990 test fishery, the potential for development of a tribal commercial fishery on northern squawfish rests on the continuance of a subsidy payment and the easing of restrictions on fishing areas and techniques imposed by

the "research fishery". The experience in the test commercial fishery in 1990 - low catch rates which resulted in fairly low levels of return to fishermen despite salary payments and provision of free gear and bait - would support this view.

Plans have been made for a meeting with various staff members of tribes and of Columbia River Inter-Tribal Fish Commission' Fish Marketing Division to discuss information on fish processing techniques and their potential for northern squawfish fishery development projects.

Legal Feasibility

The regulatory review survey form sent to the entities identified in the "Methods" section was developed to identify any problems or concerns that exist pertaining to the development of a full-scale fishery for northern squawfish. Questions were asked about existing regulations affecting northern squawfish; removal methods, time or area restrictions on harvest, requirements for handling and transporting, restrictions on disposal, required permits, management oversight, incidental catch considerations, and the administrative requirements for fishery development or rule changes. Questions were framed in the context of the three existing removal methods: dam angling, sport-reward, and commercial longline fisheries.

The following summary presents key issues identified by respondents as needing resolution for the development of a full-scale fishery for northern squawfish as a commercial, sport-reward, or dam angling fishery.,

1. Development of a full-scale commercial fishery for northern squawfish.

Several issues have been identified. Qualified participants for a commercial fishery on northern squawfish include any licensed commercial fisherman in Zones 1-5, and **only** commercial fishermen who are members of Columbia River Treaty Tribes in Zone 6 (above Bonneville Dam). Management authority for a commercial fishery would lie with the-existing commercial fishery management entities: the states of Oregon and Washington, and in Zone 6, the Nez **Perce** Tribe, the Confederated Tribes of the Umatilla Indian **Reservation**, the Confederated Tribes of the Warm Springs Reservation of Oregon, and the Confederated Tribes and Bands of the Yakima Indian Nation, assisted by the Columbia River Inter-Tribal Fish Commission.

Restrictions which may apply to end uses are reflected in the Columbia River Compact. Commercially caught fish must be sold to a **licensed** wholesale fish dealer. Oregon statute requires disposal of catch in a manner which prevents wanton waste or destruction of food fish. Standard safety requirements for fish **handling** apply, such as a limit on the time fish may remain **unchilled**. Requirements related to contaminant or other testing of northern squawfish for food products are unknown.

Concerns exist about the impact of a commercial fishery on incidental catch, particularly of salmon and steelhead. Note has **been** made of the need to closely monitor the levels of incidental catch in a commercial fishery and to devise regulations which maximize the probability for unharmed release. Enforcement of incidental catch regulations would be required.

One of the major incidental catch issues is the impact of a new or existing fishery on stocks listed or under consideration for listing as threatened or endangered under the Endangered Species Act. This type of incidental catch raises the difficult **problem** of assessing the tradeoff between the benefit of a fishery which would have the potential to reduce predation on stocks under consideration for listing, versus the potential harm to those same stocks through incidental catch mortality.

Another issue of Columbia River fisheries is the potential for fishery development to interfere with established cultural uses of that species by Native Americans. This appears not to be an issue with northern squawfish. According to the Columbia River Inter-Tribal Fish Commission, Columbia River Treaty Tribes do not place special cultural **significance** on northern **squawfish**. However, as noted above, some species with the potential to be caught incidentally to northern squawfish do have cultural significance.

Development plans for a new commercial fishery would require state administrative review, public review, and review by the governing bodies of the Nez **Perce** Tribe, the Confederated Tribes of the **Umatilla** Indian Reservation, the Confederated Tribes of the Warm Springs Reservation of Oregon, and the Confederated Tribes and Bands of the Yakima Indian Nation, assisted by the Columbia River Inter-Tribal Fish Commission. In addition, formal sanction would probably be required by the parties of *U.S. v. Oregon*.

Rule changes required to develop a commercial fishery for northern squawfish would include the reclassification of northern squawfish as a food fish in Washington.

Other considerations applying to commercial fishery development included social and management considerations which were not covered by the regulatory review questionnaire. Development of a new fishery will lead to the development of new management conditions requiring new regulations; for this reason existing regulations alone **will** not cover all potential situations arising **from** the development of a commercial fishery for northern squawfish. Social considerations related to the interaction of a northern **squawfish fishery** with other fishing activities may become as being as important as the legal feasibility of a fishery.

2. Development of a full-scale sport-reward fishery for northern squawfish.

Columbia River sport fisheries are managed by the Oregon Department of Fish and Wildlife, the Washington Department of Fisheries, and the Washington Department of Wildlife. Regulations in both Washington and Oregon apply to all sport fisheries throughout the river system. Fishery participation would be open to any **legal** sport angler and to unlicensed juveniles under age 14 in Oregon, and under age 15 in Washington. All adult anglers must hold a valid sport fishing license.

Bait and **tackle** restrictions would apply. Both Washington and Oregon prohibit the use of live bait in sport fisheries. The State of Washington restricts sport fishery tackle to a single rod, with a maximum of two hooks per line. Oregon sport fishermen are limited to three hooks and one line, or line and rod, per person.

As currently regulated, no restrictions on time of day of fishing apply. However, areas around dams are closed to sport fishing.

State regulations in both Washington and Oregon prohibit the compensation of sport anglers for catch. These restrictions are potential problems in the development of a sport-reward fishery. In Washington regulations concerning compensation for catch are covered by rules which govern fishing contests. In Oregon, a Fish and Wildlife Commission **ruling** is required to **allow** compensation for sport-caught northern squawfish. Under current regulations, northern squawfish would be restricted, as are other sport-caught fish, from being sold or wasted.

Sport-reward fisheries would need to be monitored for enforcement purposes as **well** as for purposes of evaluating impacts on incidental catch. Incidental catch of fish must be released back to the river unless of legal size and caught during an open season for that species. Sport fishery enforcement is implement&d by the State Police of each state and by deputized members of each state's fish and wildlife agency.

No regulations requiring the testing for contaminants prior to the development of a sport fishery are known.

No size limits are in effect for northern squawfish, nor do any daily limits on take apply.

Administrative and public review would be required by both states before development of a full-scale sport-reward fishery could **take** place. Administrative reviews are conducted by the Fish and **Wildlife Commission** of each state.

A potentially important issue related to the full-scale development of a **sport-reward** fishery for northern squawfish concerns access to the river by the general public. Any fishery development plan should be sensitive to the potential that issues may arise related to the ownership and use of access sites ("in-lieu sites") by non-tribal people along the lower river.

A further issue identified by the questionnaire is the quasi-commercial nature of the sport-reward fishery and the conflict of such a fishery involving nontribal members in Zone 6. At what point does payment to sport fishermen for the removal of northern squawfish constitute a commercial fishery and thus exist in conflict **with** existing regulations which provide exclusive access to Zone 6 commercial fishing to Columbia River Treaty Tribes?

3. Development of a full-scale dam angling fishery for northern squawfish.

Participation in a dam angling fishery would be limited to anglers specifically authorized by the U.S. **Army** Corps of Engineers or the appropriate Public Utility District. No public fishing from any dam structure is **allowed** without permit. This restriction would apply to all zones of the river.

Two major concerns with the conduct of a full-scale dam angling fishery are **safety** and the security of restricted areas. Safety requirements are outlined for each dam. Access permits would be required from the respective dam authorities as well as **from** the state agencies.

Oversight of safety and fishery regulations **would** be the responsibility of the state fishery management agencies. Restricted areas are defined for each dam and limit the area in which fishing would be allowed. Security restrictions would apply to access by foreign nationals to certain areas of **the** dams.

A further concern with a dam angling fishery is to minimize and monitor the impact of incidental catch, particularly of spring chinook, summer chinook, and steelhead. Angler checks would be required for enforcement. Enforcement of fishery regulations would be the responsibility of the State Police and of deputized members of the respective state's fish or wildlife agency.

Disposal of northern squawfish caught in a dam angling fishery would not be restricted, as long as disposal occurred off-site. The respective state regulations defining appropriate handling and disposal methods would apply.

Each dam administration would require details on a **specific** proposed dam angling project before a full assessment is possible.

No state administrative review process would be required for the development of a full-scale dam angling fishery.

Economic Performance

The three test fisheries were compared on the basis of respective economic performance.

Monitoring systems: An evaluation of the observer system on board the commercial fishing vessels is presented in Mathews and Iverson 1991. Interviews with commercial fishermen established that although at times the observer system was considered intrusive, overall it was not objectionable. Data forms filled in by observers provided adequate data for cost evaluation. The relevant question pertaining to the feasibility of a commercial fishery is whether the cost of the observer system is **equalled** or exceeded by the benefits accruing to the fishery in terms of either biological information or enforcement.

The sport-reward creel clerk system appeared to function effectively. Data were collected and anglers registered with overall efficiency. A summary of suggestions from creel clerks for improvements in the operations of the sport-reward fishery is **included** in the "Results. Sport-Reward **Fishery**" section of this report. Responses to the sport-reward survey form indicated the need for only minor changes in questionnaire design.

The dam angling monitoring system required two functions of the dam anglers: fish removal and fish mark and release. The performance of both tasks resulted in less than full efficiency in fish removal on the part of the dam anglers. Data forms were adequate.

Monitoring costs for each fishery account for the direct payments to agency employees (dam anglers, commercial fishery observers, and creel clerks). Direct monitoring costs for the three fisheries are compared in Table B-24. The monitoring costs per fish removed were lowest in the sport-reward fishery (\$4.42 per fish removed), higher in the commercial **longline** fishery (\$5.29 per fish removed), and highest in the dam angling fishery (\$10.01 per fish removed). Monitoring cost per unit effort was also lowest in the sport-reward fishery.

Monitoring cost per smolt saved is calculated in the following way. Two assumptions are made: 1) a constant consumption rate of three salmon smolts per northern squawfish per day; 2) an individual northern squawfish would consume **smolts** for an average of 150 days in the season if not removed. Using these numbers, we calculate the number of smolts saved, i.e. unconsumed at the end of the season, as the number of northern squawfish removed multiplied by the consumption rate of three fish per day, multiplied by the 150 days in the season. Monitoring costs for each fishery are then divided by the total number of smolts not consumed by northern squawfish to arrive at a cost-per-smolt-saved estimate. The sport-reward fishery has the lowest monitoring cost per **smolt** saved (\$.009); the dam angling fishery has the highest (\$.02).

Economic incentives to participate: Participation in the sport-reward fishery after the increase of the reward from \$1.00 to \$3.00 indicated a strong positive response to an increase of this magnitude in the economic incentive. We do not have information to evaluate the participation levels at a mid-level reward e.g. \$2.00. The \$3.00 reward appears fully adequate to induce high levels of participation in the sport-reward fishery.

It is unclear whether the combination of salary plus the \$4.00 per fish payment is adequate to induce future participation in the commercial **longline** fishery. Net revenues to fishermen are low; at these catch rates the net revenues are probably at or near fishermen's break-even points. Poor catch rates and tight restrictions on fishing conditions in the 1990 season led to low levels of enthusiasm for continuing under conditions which prohibited **normal** production fishing. However, modifications in fishery operations may alter this assessment. A summary of tribal fishermen evaluations is included in Mathews and Iverson 1991.

Operating Costs:. There are different ways to compare the cost-effectiveness of the three removal fisheries. The removal methods can be compared on the basis of cost per unit of output, cost per unit of effort, or cost per smolt saved. Table B-24 presents such a comparison on the basis of monitoring (labor) costs alone. Table B-25 presents a similar comparison of the cost-effectiveness of the three fisheries

Table B-24. Cost-Effectiveness of Monitoring **Systems** in the Commercial, **Sport-Reward**, and Dam Angling Fisheries 1990.

	Commercial Fishery	Sport-Reward Fishery	Dam Fishery	Angling
<u>Monitorinn System</u> <u>Cost per Unit*</u>				
Cost per Fish Removed	\$5.29	\$4.42	\$10.01	
Cost per Unit Effort**	\$10.55	\$9.96	\$17.29	
Cost per Smolt Saved'''	\$.01	\$.009	\$.02	
<ul style="list-style-type: none"> • Labor costs for biological monitors, creel clerks, and dam anglers. • * Effort units: Commercial = longline sets Sport Reward = angler hour Dam angling = angler hour • * See text for an explanation of calculation method. 				

Table B-25. Total Direct Agency Expenditures in the Commercial Longline, Sport-Reward and Dam Angling Fisheries 1990.

	Commercial Fishery	Sport-Reward Fishery	Dam Fishery	Angling
<u>Direct Costs</u>				
Total Cost 1990 Season	\$35,654.00	\$44,376.00	\$150,875.00	
Cost per Fish Removed	\$25.11	\$9.79	\$13.71	
Cost per Unit Effort*	\$50.07	\$13.88	\$23.67	
Cost per Smolt Saved**	\$.055	\$.02	\$.03	

• Effort units:

Commercial = **longline** sets

Sport Reward = angler hour

Dam angling = angler hour

** See text for an explanation of calculation method.

using labor costs **plus** all other direct expenditures required to operate these fisheries.

As **illustrated** in **Table B-25**, the sport-reward fishery has the lowest costs for all units of comparison: total expenditures, average cost per fish removed, average cost per unit effort, and average cost per smolt saved. It should be noted that effort **units** are not standard across fisheries; the effort unit in the commercial fishery is a **longline** set, while in the dam angling and sport reward fishery the effort unit is angler hours.

Nonmonetary costs: The test fisheries were compared on the basis of nonmonetary costs associated with their conduct. Nonmonetary costs include conflict, high **incidental** catch levels, crowding, etc. At the level of operation in 1990, none of the fisheries had high nonmonetary costs to their operation. Incidental catch levels were low (Table B-14).

Participants in the three fisheries were surveyed to elicit information about crowding or other types of conflicts. The sport-reward fishery survey forms identified a **small** number of these types of costs; some crowding on the boat ramps and in the water, some conflict between sport fishermen and commercial fishermen, and some conflict between sport fishermen and jet skis. Gear conflicts between recreational and commercial fishermen were identified as a problem by the commercial fishermen. Crowding problems were not observed with the operation of either the commercial **longline** fishery or the dam angling fishery.

DISCUSSION

Contaminant Tests

Dioxin test results have not yet been received from the Oregon Department of Environmental Quality. Processing delays at the Environmental Protection Agency Lab in Duluth, Minnesota, have delayed results beyond the expected due date of late April 1991. The prior expectation, based on other contaminant testing of northern squawfish, is that dioxin presence in both flesh and whole fish is likely to be below FDA action levels and will therefore not be an impediment to the development of food uses of northern squawfish.

Commercial Fishery

The commercial **longline** fishery accounted for the **smallest** percentage of total fish removals: 8.3%. The fishery was also the least cost-effective on most counts. The exceptions to this conclusion were monitoring cost per unit effort, at which the commercial fishery ranked second of the three fisheries, and monitoring cost per smolt saved, at which it also ranked second. Low production in the commercial fishery may have resulted **from** the constraints under which it was operating. The commercial fishery was conducted as a research fishery rather than under normal production fishing conditions. In addition, the season began late and eventually competed with the commercial salmon fishing season, raising the opportunity cost to fishermen of continuing to participate in the test fishery for northern squawfish. Any conclusions regarding the viability of a commercial fishery must be tempered by these limitations.

Suggestions by commercial fishermen for changes in commercial fishery operation are included in the "Results. Commercial Fishery" section and in Mathews et al., this volume. Expenditures associated with the 1990 commercial fishery are itemized in the "Results" section. Overall, the commercial fishery had the lowest cost-effectiveness of the three fisheries tested in 1990. Improved catch rates would significantly improve the profit position of fishermen operating in this fishery as well as lower the cost per fish removed and cost per smolt saved. Fishermen operated in 1990 very close to or possibly even below a break-even **level**. Without an increase in the monthly salary to fishermen, the only way for a fisherman to increase his level of returns is to increase his catch rate. According to the three commercial fishermen who participated in 1990, removing the "research fishery" restrictions **from** this fishery may create greater opportunities for higher levels of catch.

Sport-Reward Fishery

The sport-reward fishery accounted for the second largest proportion of the total 1990 catch: 27.4%. Catch rates and levels of participation increased sharply with an increase in the reward to \$3.00 mid-season.

It should be noted that survey data on the sport-reward fishery represents only the **successful** anglers; **i.e** those who returned to the registration site to fill out a voucher for payment. Analysis of data **from** the survey population does not, therefore, represent the experience of **all** anglers who fished for squawfish.

The sport-reward fishery attracted a diverse population of anglers which became increasingly diverse as time went on. As the season progressed, the fishery attracted anglers of a wider age range and experience level. The late season period defined by the \$3.00 reward was associated with people who had fished fewer years in the John Day pool and who traveled farther to fish there than those participating in the early season (\$1.00 reward). By late season, nearly one-third of the anglers were traveling over 100 miles to fish for northern squawfish.

The longer distances traveled to fish during Season 2 and the corresponding longer length of stay suggest a potential for greater local in-area expenditures by anglers with the higher reward level. The increased level of average expenditure per angler day in Season 2 as compared to Season 1 would support the validity of this relationship.

On the basis of the survey data, the sport-reward fishery was popular with its participants. By late season 70% of anglers said they were satisfied with the fishing experience.

The sport-reward fishery was the most cost effective fishery on all counts: Monitoring costs per fish removed, monitoring costs per unit effort, monitoring costs per smolt saved, total direct costs per fish removed, total direct costs per unit effort, and total **direct** costs per smolt saved.

Dam Angling Fishery

The dam angling fishery accounted for the largest proportion of the 1990 catch: 64.3%. Despite the success in total numbers of fish removed; this fishery involved the largest direct agency expenditures and was therefore not as cost effective as the sport-reward fishery.

The dam angling fishery had the highest monitoring costs; its costs for monitoring cost per fish caught, monitoring cost per unit effort, and monitoring cost per smolt saved were above the other **two** fisheries. Once total direct costs are accounted for, the dam angling fishery fell between the commercial fishery and the sport-reward fishery in magnitude of costs per fish removed, cost per unit effort, and cost per smolt saved.

Variation in catch rates between dams (ranging **from** .19 catch per angler hour to 3.39 catch per angler hour) suggest the potential for increasing the cost effectiveness of this fishery by concentrating effort and expenditures on the more productive dams.

Market Potential

The **deboned** frozen squawfish product appears at this time to have market potential, as a food fish-in Asian restaurants and markets. If this end use is to be pursued, some development work should 'be done on this product, **including** a process to prevent lipid oxidation, which can lead to bitterness in frozen fish, refining the deboning technique to improve cosmetic appearance, **and an** investigation of the labeling and licensing requirements for sale.

A strong recommendation of the testers in 1990 is that a name and package label be developed to portray a "cheerful" image. The current name "squawfish", is not perceived to portray a strong positive image.

The liquid fertilizer product has been successful to date. The manufacturer has expressed interest in continuing access to northern squawfish in this processing technique. The cost data presented for this process indicate potential sale price for northern squawfish to this type of production line of **\$.11 to \$.22** per kg., with an additional \$14. to **\$.20** per kg. in processing costs. Returns from this processing technique would depend on final product form, product yield weight as compared to round fish weight, and the conditions of the market. Dry fish meal represents much higher processing **costs and** lower percentage yield than liquid fertilizer, but sells for a correspondingly higher wholesale price. It would appear realistic to estimate an exvessel price of between **\$.05 and \$.10** per pound in this use.

Further discussions with this producer will be aimed at assessing the likelihood of trials with other processing techniques for northern squawfish, **i.e.** for skins, glands and flesh. To date, the current tester has not tested these alternative techniques. We will pursue other outlets for these tests is we continue to be unable to test these through the current source.

On the basis of the 1990 test, the fish meal product does not appear to hold promise for further tests. We will **follow** up with the manufacturer this winter to determine if conditions surrounding the 1990 test in this process were irregular, and if not, pursue other manufacturing outlets for testing this process.

The use of northern squawfish as bait appears to be viable more for crayfish bait than for crab bait. Either use **will** be relatively small-scale. The crayfish fishery would be an outlet for approximately 909 kg. per week during the crayfish season, at a projected **price** of **\$.22** per kg. Low volumes combined with low estimated prices place northern squawfish at bait at the low end of the **utilization** possibilities.

We will pursue the potential for another large-scale use of northern squawfish for 1991. We plan to contact a pet food manufacturer to assess the level of interest in testing northern squawfish in this process.

With regard to the collection, transportation, storage and delivery system, it appears that the most efficient strategy for transporting northern **squawfish** carcasses is to allow **them** to accumulate in **freezers** until a large volume can be picked up at one time. Trucking cost per kg. mile decreases as volume transported increases. Several factors limited the volume which could be handled in a single trip in 1990, including limited space and variable **fill-up** rates of **freezers** at harvest sites, the need to deliver in rapid time to cold storage facilities, and the lack of a large volume truck equipped with a lift.

Several problems related to the collection, transportation, storage and delivery system were **identified**, including incompatible height of the truck bed, the difficulty of manual transfer of fish from chest freezers to totes, inadequate access to chest **freezers** on dams, and difficulties freezing large quantities of northern squawfish placed in close succession in chest freezers. These problems and recommendations for improvements. in the 1991 fishing season are discussed in **detail** in Appendix B-7.

Tribal Fishery Potential

The potential for a commercial tribal fishery for northern squawfish appears good subject to certain changes in operating conditions, outlined above. Further assessment of **tribal** interest in conducting either a fishery or a processing operation is continuing. Interest in processing or marketing will likely depend on the assessment of likely markets and on the technical requirements and specifications of processing techniques.

Legal Feasibility

Development of full-scale commercial, sport-reward, or dam **angling** fisheries on northern squawfish are feasible subject to certain constraints and conditions, outlined above in the "Results. Legal Feasibility" section. Fishery **implementation** planning should include these noted conditions as checkpoints in fishery development.

Economic Performance

The three removal methods have been compared on the basis of their cost effectiveness, using different measures. These comparisons are discussed in the "Results" section. Comparisons have also been made on the economic incentives to participate, nonmonetary costs, and monitoring systems. A general conclusion about all three fisheries is that as presently structured, each will require some level of subsidization to maintain. None of the fisheries are as yet associated with large potential economic returns. A relevant question for continuation of these three removal methods is which method requires the lowest level of subsidization to maintain? On the basis of the 1990 experience and scale of operation, the answer to this question would be the sport-reward fishery. However, changes in either operating conditions or scale of operation of any of the fisheries might alter this conclusion.

It is **also** appropriate to look at performance measures other than cost-effectiveness which may be achieved by the three fisheries. Examples of other returns from a fishery include generation of **local** economic impact, increased employment, or increased recreational fishing opportunities for anglers.

Local economic impact: both the sport-reward and the commercial fishery involve generation of some **local** economic impact as expenditures are made in the **local** economy. To the extent that dam anglers live in the areas of the dams, their wages **also** represent some infusion of dollars into the local economy as money is spent for housing, food, and services.

Increased employment: the commercial fishery provides employment opportunity for Native American fishermen as well as for agency personnel who serve as biological monitors. The sport-reward fishery employs registration **clerks** on a seasonal basis. The dam angling fishery employs anglers to fish on darns as well as some monitoring personnel.

Increased recreational fishing opportunities for anglers: the sport-reward fishery provided **recreational** fishing opportunities to 2,376 anglers in 1990. An increase in the number of registration sites to anglers combined with an increase in the number of hours sites remained open would probably increase the level of recreational participation.

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APPENDIX B-1.

Commercial Longline Fishery Data Forms

B-1.1. Commercial **Longline** Fishery Cost Data Form

NORTHERN SQUAWFISH COMMERCIAL FISHERY DAILY LOG

ODFW OBSERVER _____

CREW MEMBERS _____

BAIT TYPE _____

WEATHER _____

DOCUMENT NUMBER _____

PAGE _____ OF _____

DATE			TOTAL TIME OUT (HOURS)	FUEL USED (GALLONS)	#'S OF BAIT USED
MONTH	DAY	YEAR			

	NUMBERS CAUGHT	WEIGHT (KG)			MARKET
SQF					
WAL					
CHC					
SMB					

OPERATING COSTS:

FUEL	\$---	OTHER EXPENSES (specify)	
OIL	\$---		\$---
ICE	\$---		\$---
ENGINE MAINTENANCE	\$---		\$---
CREW	\$---		\$---
FOOD AND SUPPLIES	\$---		\$---

DISTANCE TRAVELED TO FISHING SITE (1WAY) _____ MILES

COMMENTS _____

COMMLOG.DRW 3-6-90

B-1.2. Commercial Longline Fishery Exit Interview Form (*Economics*)

EXIT INTERVIEW
COMMERCIAL **LONGLINE FISHERMEN**
SUMMER 1990

Interviewer _____ Date _____ Fisherman _____

1. How long have you been fishing on the **Columbia River**?
2. What species do you normally fish for?
3. Did you use your regular crew **to** fish for squawfish?
4. Do you usually market your own fish or **sell** to a buyer?
5. Can you think of any market possibilities for squawfish?
6. If answer to **#5** is yes, what price do you think squawfish could sell for?
7. Do you think there is any potential for a **commercial** fishery for **squawfish**?
8. If answer to **#7** is yes, what do you think would be the best way to set up and operate the commercial fishery?

THANK YOU.

APPENDIX B-2.

Sport-Reward Fishery Survey Form

Members of a single household fishing together: Main angler in household answer questions for entire household. Members of separate households fishing individually or together: Each registered angler should answer questions for him/her self. (If group expenditures made for #7,8,9, enter amount of your individual expenditure only.)

PLEASE CIRCLE THE APPROPRIATE ANSWER

1. Number of anglers in your party:
_____ PEOPLE
2. Number of hours actually spent fishing on this trip: _____ HRS (PER PERSON)
3. Years you have fished at this reservoir:
 1. <1 3. 4-5
 2. 1-3 4. >5
4. Miles traveled (one way) to fish for squawfish this trip:
 1. <20 4. 60-79
 2. 20-39 5. 80-99
 3. 40-59 6. 100 or more
5. Number of days you stayed in the area this trip:
 1. <1 5. 4
 2. 1 6. 5
 3. 2 7. >5
 4. 3
6. If you stayed overnight, type of accomodation:
 1. MOTEL
 2. STATE PARK
 3. NATIONAL PARK CAMPGROUND
 4. PRIVATE CAMPGROUND
 5. FRIEND OR RELATIVE
 6. OTHER (please specify): _____
7. Amount spent on accommodations:
\$ _____
8. Approximate amount spent to purchase food in the area:
 1. RESTAURANTS: \$ _____
 2. GROCERY STORE: \$ _____
 3. OTHER (please specify): \$ _____
9. Other expenditures in the area:
 1. GAS: \$ _____
 2. FISHING SUPPLIES: \$ _____
 3. BAIT: \$ _____
 4. OTHER (please specify): \$ _____
10. Fishing method(s) you/(your party) used:
(circle as many as apply)
 1. BOAT, ANCHORED
 2. BOAT, DRIFTING
 3. BOAT, TROLLING
 4. SHORE
 5. ANGLING, SURFACE
 6. ANGLING, BOTTOM
 7. OTHER (please specify): _____
11. Bait or tackle you/(your party) used:
(circle as many as apply)
 1. WORMS
 2. CUT FISH BAIT
 3. SPINNERS
 4. SPOONS
 5. FLATFISH
 6. SURFACE PLUGS
 7. HOOK AND LINE WITH 1 HOOK
 8. HOOK AND LINE WITH >1 HOOK
 9. OTHER (please specify): _____
12. Approximate purchase price of the tackle you circled in #11: \$ _____
13. Number of *squawfish* you/(your party) threw back this trip: _____
14. Besides squawfish, did you catch any of the following:

1. WALLEYE	NUMBER _____
2. STURGEON	NUMBER _____
3. SMALLMOUTH BASS	NUMBER _____
4. CATFISH	NUMBER _____
5. SALMON	NUMBER _____
6. STEELHEAD	NUMBER _____
7. SHAD	NUMBER _____
8. CARP	NUMBER _____
9. SUCKER	NUMBER _____
10. OTHER (please specify):	_____
15. What is your opinion of this squawfish fishing experience?
 1. SATISFIED
 2. INDIFFERENT
 3. NOT SATISFIED

16. Have you fished for squawfish before?

1. YES
2. NO

17. Have you ever caught squawfish while fishing for another species?

1. YES, OFTEN
2. YES, OCCASIONALLY
3. NO

18. If answer to #17 is yes, what did you do with the squawfish you caught before?
(Circle as many as apply)

1. ATE
2. GAVE AWAY FOR OTHERS TO EAT
3. FED TO ANIMALS
4. USED AS FERTILIZER
5. THREW AWAY
6. RELEASED BACK TO RIVER
7. OTHER (please specify): _____

19. Have you ever eaten squawfish in any form?

1. YES
2. NO

20. If answer to #19 is yes, how would you rate squawfish quality (taste and texture)?

1. VERY SATISFACTORY
2. SATISFACTORY
3. UNSATISFACTORY

21. How many fishing trips do you usually make per year?

- | | |
|----------|----------|
| 1. 0 | 5. 16-20 |
| 2. 1-5 | 6. 21-25 |
| 3. 6-10 | 7. >25 |
| 4. 11-15 | |

22. Do you plan to fish for squawfish again this summer?

1. YES
2. NO

23. What species do you fish for in:

1. SUMMER _____
2. FALL _____
3. WINTER _____
4. SPRING _____

24. State of residence:

1. OREGON
2. WASHINGTON
3. IDAHO
4. OTHER (specify): _____

25. Age (circle as many as apply):

- | | |
|----------|----------|
| 1. 14-20 | 5. 51-60 |
| 2. 21-30 | 6. 61-70 |
| 3. 31-40 | 7. >70 |
| 4. 41-50 | |

26. Any problems encountered with other fishermen:

1. ON BOAT RAMP (please specify): _____
2. ON WATER (please specify): _____

COMMENTS: _____

THANK YOU FOR YOUR HELP AND TIME.

APPENDIX B-3.

Utilization Trials Data Forms

B-3.1. ~~Deboned~~ Minced Product Evaluation Form

RESTAURANT AND MARKET SURVEY
DEBONED NORTHERN SQUAWFISH PRODUCT

Business: _____

Delivery Date: _____

Interview Date: _____

1. Number of pounds in delivery _____
2. Preparation methods used, products made:
 1. _____
 2. _____
 3. _____
 4. _____
 5. _____
 6. _____
3. Uses of product (circle as many as apply):
 1. home consumption
 2. restaurant dish
 3. marketed unprepared, frozen
 4. marketed unprepared, thawed
 5. marketed prepared, uncooked
 6. marketed prepared, cooked
4. Was product a) sold b) given away c) consumed within business

-

- | | | | |
|-------------------|----------------|--------------|------------|
| quality: | a) very poor | b) poor | c) average |
| | d) good | e) very good | |
| appearance: | a) very poor | b) poor | c) average |
| | d) good | e) very good | |
| taste: | a) very poor | b) poor | c) average |
| | d) good | e) very good | |
| ease of handling: | a) very poor | b) poor | c) average |
| | d) good | e) very good | |

- | | | | |
|--------------------|----------------|--------------|------------|
| flesh color: | a) very poor | b) poor | c) average |
| | d) good | e) very good | |
| package form: | a) very poor | b) poor | c) average |
| | d) good | e) very good | |
| package size: | a) very poor | b) poor | c) average |
| | d) good | e) very good | |
| product | | | |
| uniformity: | a) very poor | b) poor | c) average |
| | d) good | e) very good | |

8. Product attributes important to you in your business:

	<u>Not</u> <u>Important</u>											<u>Very</u> <u>Important</u>
Price:	N/A	0	1	2	3	4	5	6	7	8	9	10
Product form	N/A	0	1	2	3	4	5	6	7	8	9	10
Flesh color:	N/A	0	1	2	3	4	5	6	7	8	9	10
Flesh texture:	N/A	0	1	2	3	4	5	6	7	8	9	10
Taste:	N/A	0	1	2	3	4	5	6	7	8	9	10
Package form	N/A	0	1	2	3	4	5	6	7	8	9	10
Package size:	N/A	0	1	2	3	4	5	6	7	8	9	10
Product uniformity:	N/A	0	1	2	3	4	5	6	7	8	9	10
Labeling:	N/A	0	1	2	3	4	5	6	7	8	9	10
Shelf life:	N/A	0	1	2	3	4	5	6	7	8	9	10
Supply availability (months/yr.)	N/A	0	1	2	3	4	5	6	7	8	9	10
Product name:	N/A	0	1	2	3	4	5	6	7	8	9	10
Ease of handling:	N/A	0	1	2	3	4	5	6	7	8	9	10
Other (specify):	N/A	0	1	2	3	4	5	6	7	8	9	10

9. Assessment of market potential of deboned northern squawfish:

1. excellent

2. good

3. some

4. little

5. none

10. Assessment of wholesale price your business willing to pay for this product (circle one):

1. 0

6. 1.01 - 1.25

2. .01 - .25

7. 1.26 - 1.50

3. .26 - .50

8. 1.51 - 1.75

4. .51 - .75

9. 1.76 - 2.00

5. .76 - 1.00

10. > 2.00

11. At price indicated above, please specify quantity (per year) your business might handle.

12. **Assessment of retail price you could charge for frozen deboned product (per package):**

- | | |
|-----------------------|----------------|
| 1. .50 - .74 | 6. 1.75 - 1.99 |
| 2. .75 - .99 | 7. 2.00 - 2.24 |
| 3. 1.00 - 1.24 | 8. 2.25 - 2.49 |
| 4. 1.25 - 1.49 | 9. \geq 2.50 |
| 5. 1.50 - 1.74 | 10. N/A |

13. **Assessment of retail price you could charge for prepared product (specify form):**

- | | |
|----------------|---------------------------|
| 1. 1.00 - 1.99 | 5. 5.00 - 5.99 |
| 2. 2.00 - 2.99 | 6. 6.00 - 6.99 |
| 3. 3.00 - 3.99 | 7. 7.00 - 7.99 |
| 4. 4.00 - 4.99 | 8. \geq 8.00 |

14. **Specify any problems you experienced with deboned squawfish product:**

15. **Suggestions for improvement of deboned squawfish product:.**

16. **Other comments:**

B-3.2. Processing Trials Data Form

1. Trial ID: _____

2. Subject ID: _____

3. Date: _____

4. Time: _____

5. Trial Type: _____

6. Trial Description: _____

7. Trial Results: _____

8. Trial Comments: _____

9. Trial Status: _____

10. Trial Date: _____

11. Trial Time: _____

12. Trial Location: _____

13. Trial Duration: _____

14. Trial Frequency: _____

15. Trial Intensity: _____

16. Trial Complexity: _____

17. Trial Difficulty: _____

18. Trial Motivation: _____

19. Trial Focus: _____

20. Trial Attention: _____

21. Trial Memory: _____

22. Trial Reasoning: _____

23. Trial Emotion: _____

24. Trial Behavior: _____

25. Trial Cognition: _____

26. Trial Perception: _____

27. Trial Judgment: _____

28. Trial Decision: _____

29. Trial Action: _____

30. Trial Outcome: _____

Feasibility of Commercial and Bounty Fisheries
for Northern Squawfish
Cooperative Research Project
Oregon Department of Fish and Wildlife
Oregon State University
University of Washington

BUSINESS

BUSINESS ADDRESS

1. How many pounds of squawfish did you receive in the delivery?

2. What experiments did you run with the squawfish?

3. Please give us your best estimate of which parts of squawfish are suitable for processing:

	Yes	No
Flesh		
Skin		
Glands		
Other (specify)		

4. We are interested in the cost of processing squawfish in the manner you have used in this trial. Please give us your best estimate of approximate costs for the following items:

	Time Used	Rate (\$/hr.)	Total Cost
Labor			
Materials			
Other (please specify)			
Other (please specify)			
Other (please specify)			

5. Do you think a commercial use of squawfish is feasible in the type of processing you performed?

Yes _____ No _____

6. What would be the maximum price per pound you would be willing to pay for squawfish processed in this way?

7. Do you have suggestions for other commercial uses of squawfish?

8. Are you interested in receiving more (additional deliveries or larger volumes) of squawfish for processing?

Yes _____ No _____

B-3.3. Bait Marketing Data Form

FEASIBILITY OF COMMERCIAL AND BOUNTY FISHERIES
FOR NORTHERN SQUAWFISH

COOPERATIVE RESEARCH PROJECT
OREGON DEPARTMENT OF FISH AND WILDLIFE
OREGON STATE UNIVERSITY
UNIVERSITY OF WASHINGTON

SQUAWFISH TEST UTILIZATION SURVEY

DATE _____

B U S I N E S S

BUSINESS ADDRESS

1. HOW MANY FISH DID YOU RECEIVE IN. THIS DELIVERY?

	LIVE	ICED	FROZEN
EXTRA LARGE (over 3 lbs.)			
LARGE (2-3 lbs.)			
MEDIUM (1-2 lbs.)			
SMALL (under 1 lb.)			

2. IF THE FISH WERE NOT SEPARATED BY SIZE, WHAT WAS THE TOTAL WEIGHT OF THE DELIVERY?

3. IN WHAT FORM WERE THE FISH DELIVERED?

LIVE _____ ICED _____ FROZEN _____

4. HOW WERE THE SQUAWFISH USED? _____

5. WHAT PRICE DID YOU RECEIVE FOR THE SQUAWFISH?

	PRICE PER LB.
< 1 LB.	
1-2 LB.	
2-3 LB.	
> 3 LB.	
MIXED SIZES	

6. DID YOU PREPARE THE SQUAWFISH FOR SALE? YES _____ NO _____

7. IF YOUR ANSWER TO #7 IS YES, WHAT DID YOU DO TO PREPARE THE SQUAWFISH FOR SALE?

8. HOW MUCH DID IT COST TO PREPARE THE SQUAWFISH FOR SALE?

9. HOW MUCH TIME DID IT TAKE YOU TO PREPARE THE SQUAWFISH FOR
S A L E ?

10. DID YOU DELIVER THE SQUAWFISH TO YOUR BUYERS? YES _____ NO _____

11. IF YOUR ANSWER TO #9 IS YES, HOW FAR DID YOU TRAVEL TO DELIVER
THE FISH?

12. WHAT DELIVERY COSTS DID YOU INCUR?

13. OTHER COSTS

14. WHAT QUANTITY OF SQUAWFISH DO YOU THINK YOU WOULD BE ABLE TO
SELL FOR THIS END USE?

15. CAN YOU SUGGEST OTHER POTENTIAL USES FOR SQUAWFISH?

16. DO YOU HAVE ANY COMMENTS ON ANY ASPECT OF THE TEST MARKETING?

THANK YOU FOR YOUR TIME.

APPENDIX B-4.

Regulatory Review Questionnaire



NEIL GOLDSCHMIDT
GOVERNOR

Department of Fish and Wildlife

2501 SW FIRST AVENUE, PO BOX 59, PORTLAND, OREGON 97207 PHONE (503) 229-5400

August 23, 1990

To: Distribution

From: Jim Martin, Chief, Fish Division

Re: Squawfish Fisheries Regulatory Review

The Oregon Department of Fish and Wildlife (ODFW) and Oregon State University (OSU) are assessing regulatory concerns related to potential development of fisheries and various end uses of northern squawfish in the Columbia River as part of BPA-funded projects 82-012 and 90-077. Enclosed is a questionnaire prepared by ODFW and OSU that will be used to develop an implementation plan that identifies actions that must occur prior to or concurrent with fishery implementation to ensure compliance with rules and regulations of entities under whose jurisdiction squawfish fisheries activities will fall.

Please forward the questionnaire to the appropriate person(s) within your organization for their consideration. Completed questionnaires should be returned by October 1, 1990 to Dr. Susan Hanna, Department of Agricultural and

- Resource Economics, Ballard Hall 200, Oregon State University, Corvallis, OR 97331-3601. If you have any questions please contact Dr. Hanna at (503) 737-1437 or Ron Boyce at (503) 229-5410 EXT 351.

Thank you for your cooperation.

- Attachment

Distribution:

CBFWA Members

Jack Donaldson

F P A C

Bill Maslen (BPA)

Jim Athearn (Corps-NPD)

Gary Johnson (Corps-NPP)

Dave Hurson (Corps-NPW)

Don Ziegler (Grant Co PUD)

Dick Nason (Chelan Co PUD)

Mike Erho (Douglas Co PUD)

Ray Kindley (PNUCC)

Susan Hanna (OSU)

Emery Wagner, Tony Nigro, Steve Vigg, Doug DeHart, Frank
Young, Ron Boyce, Ray Temple, Al Smith, Kay Brown, Jim
Glasdon (ODFW)

Rules and Regulations Required for Implementation of Fisheries to Control Northern Squawfish Populations in the Columbia River Basin

Introduction :

Mortality of juvenile salmon and steelhead in reservoirs throughout the Columbia River Basin is a major problem caused by development and operation of the hydropower system (NPPC 1987, Section 206(b) (1)(A)). One of the sources of juvenile salmon and steelhead mortality in reservoirs is predation by resident fish, particularly northern squawfish (Poe. and Rieman, editors 1988). Under the Columbia Basin Fish and Wildlife Program, Bonneville Power Administration (BPA) is directed to "... continue its existing study and fund any further studies necessary to investigate juvenile salmon and steelhead losses to predators..." This questionnaire is part of studies investigating whether losses to predators can be reduced by harvesting northern squawfish.

Three methods to harvest northern squawfish are being tested in 1990, any of which may be recommended for implementation in 1991. A longline fishery involving three tribal fisher crews and a recreational reward-fishery involving the angling public are being tested in John Day Reservoir. A hook and line fishery involving Oregon Department of Fish and Wildlife (ODFW) seasonal personnel is being tested in tailraces and forebays of Bonneville, The Dalles, John Day, McNary and Ice Harbor dams. Fishery management agencies, tribes and power interests, through the NPPC Reservoir Mortality/Water Budget Effectiveness Technical Work Group, reviewed and approved the study. For 1990, BPA, ODFW, Washington Department of Wildlife (WDW) and U.S. Army Corps of Engineers (USACE) were individually consulted as needed to ensure compliance with or identify the need for rules and regulations to conduct the test fisheries. These agencies were consulted because some test fisheries activities fell under their jurisdiction.

A brief description of each of the 1990 test fisheries follows. If deemed feasible and necessary, one or more of the fisheries may be implemented in 1991 in the Columbia River between Bonneville and Priest Rapids dams and in the Snake River downstream from Ice Harbor Dam. The fisheries may be expanded to the Snake River between Ice Harbor and Hells Canyon dams in 1992 and the Columbia River between Priest Rapids and Chief Joseph dams in 1993. Although some specifics may change with implementation of a fishery, the general approach should be the same as the test fishery.

The longline fishery is being conducted in John Day Reservoir employing three tribal fisher crews. Each crew consists of two tribal members; an ODFW observer is also aboard each boat. The fishery began June 12 and runs through August 10. Crews fish Monday through Thursday. The reservoir is divided into three sections for the test. Each crew fishes one section each week; each crew fishes all three sections over a three-week period. Approximately 10 longlines containing about 50 baited hooks each are fished by each crew per day. Lines are set for 6 to 8 hours. Northern squawfish are held on ice, all other fish are released. ODFW observers verify northern squawfish catch and issue receipts to crew leaders at end of each fishing day. Crews submit receipts and invoice for hours fished to ODFW for payment.

The recreational reward-fishery is also being conducted in John Day Reservoir. For the fishery, the reservoir includes backwaters, sloughs and impounded reaches of tributaries; in the John Day River, the impounded reach is defined as the area from its confluence with the Columbia River upstream approximately 9 miles to an area commonly called 'The Narrows' and in the Umatilla River, the impounded reach is defined as the area from its confluence with the Columbia River upstream approximately 3 miles to the Three Mile Dam tailrace. The fishery began May 24 and runs through September 3. The fishery is conducted four days each week (Thursday through Sunday), and on Memorial and Labor days. Anglers must register at one of four sites each day they participate in the fishery. Fish must be presented for rewards each day at the site where the angler registered. A reward is paid for each northern squawfish with a total length of 11 inches or more. Rewards are paid when completed vouchers and questionnaires issued at registration sites are returned to ODFW.

The hook and line fishery is being conducted from five dams on the Columbia and Snake rivers. Twenty two anglers, employed as seasonal aides by ODFW, fish from the dams. Eight anglers are stationed at Bonneville Dam, four each at The Dalles, John Day and McNary dams and two at Ice Harbor Dam. Half the anglers fish the tailraces and half tie anglers fish the forebays, except at Ice Harbor Dam where both anglers fish the tailrace. Anglers began fishing April 30 and will fish through August 31. Anglers work five 8-hour days per week. Various hours of the day, baits and tackle are being tested to identify best fishing methods.

Consultations with BPA, ODFW, WDW and USACE resulted in several policy decisions and actions necessary to enable 1990 test fishing. EPA determined that NEPA regulations allowed their funding of the test fisheries in 1990 because the program was experimental. However, BPA identified the need for NEPA evaluation prior to implementation in 1991. ODFW determined the only rules and regulations that applied to the longline fishery were those for awarding contracts because the fishery involved three tribal fisher crews under contract to ODFW; selection was coordinated with the Columbia River Intertribal Fish Commission and fishery biologists of member tribes. ODFW also determined that a special rule was needed for the recreational reward-fishery because ODFW was conducting the test and the fishery involved payments to the angling public as incentive to harvest northern squawfish; the Oregon Fish and Wildlife Commission approved the rule. WDW allowed the recreational reward-fishery to be conducted from the Washington-shore in 1990 under Oregon's special rule. However, WDW identified the need for more formal review of its rules and regulations prior to fishery implementation. USACE determined safety rules and regulations governing activities on their projects applied to the hook and line fishery by ODFW employees; ODFW complied prior to initiating the test fishery.

Implementation of any of the fishery alternatives tested in 1990 will require review and approval by regional fishery management agencies, tribes and power interests. The review process should document concerns and actions required to address those concerns prior to fishery implementation. To facilitate the review process, the following questions are designed to identify concerns and define actions necessary to address those concerns.

COMMERCIAL FISHERY

1. What gear types are legal for commercial fisheries on the Columbia River?

2. Who manages commercial fisheries on the Columbia River within or bordering your state?

3. Are commercial fisheries on the Columbia River regulated by seasons or time-of-day restrictions? If yes, please specify.

4. Are area closures for commercial fishing in effect? If yes, please specify.

5. Are there regulations dictating the handling of incidental catch?. If yes, please specify.

6. Are size restrictions in effect for commercially caught fish? If yes, please specify.

7. Are there restrictions on who could participate in commercial fisheries on the Columbia River? If yes, please specify.

- a. Is participation in commercial fisheries on the Columbia River regulated by zone?
If yes, please specify.

9. Are there restrictions placed on end uses or disposal of commercially caught fish?
If yes, please specify.

10. Are there restrictions placed on the handling of catch for various end' uses? If
yes, please specify.

11. -What permits are needed to catch, hold, or transport fish?

INSTATE:

Catch: _____

Hold: _____

Transport: _____

OUT OF STATE:

Catch: _____

Hold: _____

Transport: _____

- 12 Are commercial sales restricted to a particular source? (i.e. a buyer or broker). If
yes, please specify.

13. Would **contaminant** testing of other "quality **control**" measures be required to market **northern** squawfish? If yes, which agency is responsible for oversight?

14. What agency is responsible for commercial fishery enforcement on the Columbia River?

15. Would oversight of a **commercial** fishery for **northern** squawfish require **onboard** monitoring or other enforcement mechanisms?

16. Is there an administrative review **process** (Legislative, Commission, etc.) required for **new commercial fishery development**? If yes, please specify **schedule** and **activities**.

17. Is there a public review **process** required for new **commercial** fishery development? If yes, please specify **schedule** and activities.

18. **With** whom would you share management responsibility for a **commercial** fishery on northern **squawfish**?

19. Are there any **compacts** or treaties which would apply to a commercial fishery on **northern** squawfish? If yes, **please** specify.

20. Are there agency or tribal policies regarding other species or Threatened and Endangered Species that a commercial fishery on **northern** squawfish would affect? If yes, please specify.

21. Would any federal laws apply to a commercial fishery for northern squawfish? **E.G.** Threatened and Endangered, **NEPA**, Marine Mammal Protection Act, etc. If yes, what agency(s) is responsible for oversight?

22. Are **commercial** fishery regulations the same for all areas of the Columbia under your jurisdiction? Are there different management zones and **different regulations** for each? If yes, please specify.

23. Would Commission presentations, reviews and approval be required to implement a **commercial** fishery on **northern squawfish**? If yes, please **describe** the process; schedule, documentation, etc.

SPORT REWARD FISHERY

1. What **tackle restrictions** are in effect for sport fisheries on the Columbia River?

2. What bait **restrictions** are in effect for sport **fisheries** on the Columbia River?

3. Who manages sport fisheries on the Columbia River within or bordering your state?

4. Are sport fisheries on the Columbia River regulated by seasons or time-of-day **restrictions**? If yes, please specify.

5. Are area closures for sport fishing in effect? If yes, please specify.

6. **Are** there any **regulations** prohibiting sport anglers from being compensated for catch? If yes, please specify.

7. If compensation for sport **catch** is allowed, what restrictions **apply**?

8. Are ~~there~~ regulations dictating the **handling** of incidental catch in a **sport fishery**?
If yes, **please specify**.

9. Are size **restrictions** in effect for **sport caught** fish? If yes, please specify.

10. Are numbers of sport caught fish **regulated, i.e.**, by daily or **seasonal** limits? If yes, please specify.

- II. Are there restrictions on whci could participate in, sport fisheries on the Columbia **River**? If yes; please **specify**.

12. Is **participation in** sport fisheries on the Columbia **River** regufated by zone? If yes, please specify.

13. Are there restrictions placed on end uses or **disposal** of sport caught fish? If yes, please specify.

14. Are there restrictions placed on the **handling** of **sport** catch for various end uses?
If yes, please specify.

15. What permits are needed to catch, hold, or transport sport caught **fi sh**?

INSTATE:

Catch: _____

Hold: _____

Transport: _____

OUT OF STATE:

Catch: _____

Hold: _____

Transport: _____

16. Would contaminant testing of other "**quality** control" measures be required before development of a sport fishery for northern **squawfish**? If yes, **which** agency is responsible for oversight?

17. What agency is responsible for sport *fishery* enforcement on the Columbia **River**?

18. What enforcement mechanisms would be required for oversight of a sport fishery for northern **squawfish**?

19. Is there an **administrative** review process (Legislative, **Commission**, etc.) required for new **sport** fishery development? If yes, please specify schedule and activities.

20. **Is** there a public review process required for new sport *fishery development*? If yes, please specify schedule and activities.

21. **With** whom would you share management responsibility for a sport fishery on northern **squawfish**?

22. Are there any compacts or treaties which would **apply** to a sport fishery on **northern** squawfish? If yes, please specify.

23. Are there agency or tribal policies regarding other species **or** Threatened and Endangered Species that a sport fishery on northern **squawfish** would **affect**? If yes, please specify.

24. Would any **federal** laws apply to a sport fishery for northern **squawfish**? E.G. Threatened and Endangered, **NEPA**, Marine Mammal Protection Act, etc. If yes, what agency(s) is responsible for oversight?

25. Are sport fishery **regulations** the same for all areas of the Columbia River under your jurisdiction? Are there different management zones and different **regulations** for each? If yes, please specify.

26. Would Commission presentations, reviews and approval **be required** to implement a sport fishery on northern **squawfish**? If yes, please **describe** the process; schedule, documentation, etc.

DAM ANGLING FISHERY

1. Does your agency/organization have any personnel rules prohibiting angling for northern squawfish from dams? If yes, please specify.

2. Are there restrictions on who could participate in a dam angling fishery on the Columbia River? If yes, please specify.

3. What permits would be required for a dam angling fishery?

4. Would participation in a dam angling fishery on the Columbia River be regulated by zone? If yes, please specify.

5. Would restrictions be placed on end uses or disposal of northern squawfish caught in a dam angling fishery? If yes, please specify.

6. What agency would be responsible for dam angling fishery enforcement on the Columbia River?

7. What enforcement mechanisms **would** be required for oversight of a dam angling fishery for northern squawfish?

8. Would an administrative review process (Legislative, Commission, etc.) be required for a new dam angling fishery? If yes, please specify schedule and activities.

9. Would a public review **process** be required for development of a dam angling fishery? If yes, please specify **schedule** and activities.

10. **With** whom would you share management responsibility for a dam **angling** fishery on northern squawfish?

11. Are there any compacts **or** treaties which would apply to a **dam angling** fishery on northern **squawfish**? If yes, please specify.

12. Are *there* agency or tribal policies regarding other species or Threatened and Endangered Species that a dam angling fishery on **northern** squawfish would affect? If yes, please **specify**.

13. Would any federal laws apply to a dam angling fishery for northern squawfish? .
E.G. Threatened and Endangered, NEPA, Marine Mammal Protection Act, etc. If
yes, what agency(s) is responsible for oversight?

GENERAL FISHERY QUESTIONS

1. Within your state/organization who is your **contact** person for the following:

Name

Phone

Fish quality control

Fishery management

Fishery development

Fish marketing/disposition

- 2 Does your state/organization have any programs for developing new fisheries on **underutilized** species? If yes, please specify.

- 3 Does your state/organization have any pest control or other programs that may encompass the goal of the northern **squawfish** fishery? If yes, please specify.

- 4 If the **answer** to Questions # 2 or 3 is no, are there other organizations/agencies **you feel** we should contact regarding these issues? If yes, please specify.

APPENDIX B-5.

Results of Tests for Dioxin Presence in Northern Squawfish

No dioxin analysis results available as of 7/18/91

APPENDIX B-6.

Report on the 1990 Squawfish Derby

**REPORT ON THE FIRST ANNUAL SQUAWFISH FISHING DERBY
VANTAGE, WASHINGTON, JULY 21-22, 1990**

**Susan Hanna
Department of Agricultural and Resource Economics
Oregon State University**

October 1990

The author thanks David Brooks, Atse Yapi, and Mary Brock for assistance in data collection, data entry, figure preparation and manuscript preparation.

REPORT ON THE FIRST ANNUAL SQUAWFISH FISHING DERBY VANTAGE, WASHINGTON, JULY 21-22, 1990

The first of what is planned to be an **annual** squawfish derby was held in the Wanapum Reservoir of the Columbia River on July 21 and 22, 1990. The derby was organized and conducted by the Washington Game Protectors for the purpose of **squawfish removal**.

Washington Game Protectors (WGP) is a 16 member organization based in Tacoma Washington. Mark Strickland of WGP was the derby chair, thirteen other members were present at this derby. Proceeds from the derby will go to the WGP for use in habitat protection and enhancement projects. The WGP is currently conducting a rainbow trout rearing project in the Wanapum Pool.

Derby Planning and Coordination

Derby Objective

The objective of the derby was to remove a large number of northern squawfish from the Wanapum pool. The WGP is interested in the development of sport fisheries in this reservoir; reduction and control of the squaw-fish population is seen as a precondition for enhancement of sport fish populations.

Registration

Registration for the derby took place by mail in advance of the derby and at the derby site. One hundred and two people registered for the derby, including 7 children.. Of the 102 registered participants, 88 reported to the weigh-in site at the end of the first day; 47 at the end of the second day. Registration fees were \$25 for adults (age 16 and over), \$10 for children (15 years and younger). Registration was required for each individual fishing.

Regulations

The Washington Game Protectors established the following rules for the derby. The list is taken verbatim from the derby handbook provided to each derby participant.

1. Start times are 8 AM. Saturday and Sunday. Finishing times are 4 P.M. Saturday and 2 P.M. Sunday. Start times are on the honor system rather than a starting line.

2. All competitors must be at the official weigh-in station by **4:00 P.M.** on Saturday and **2:00 P.M.** Sunday.
3. Each contestant late to the weigh-in station on either day will be penalized 3 pounds for every **5** minutes, up to **15** minutes late. After 15 minutes this is grounds for disqualification of each contestant involved.
4. **All** fish must be caught by rod and reel in a sporting manner complying with all local and state laws.
5. There is no limit regulation on **squawfish**, but there is a state wastage regulation.
6. The contestant must select their own largest (heaviest) squawfish to be weighed separately.
7. The total catch **will** be weighed, adding to the weight of the designated heaviest fish to be a total for each day.
8. Sunday, July 22, the weight of both days, Saturday and Sunday will be compiled for a grand total. This total weight **will** be posted Sunday after the tournament,
9. Each contestant 's catch will be weighed on a certified scale **that** weighs to one hundredth of a pound.

Prize Categories

The tournament had two separate classes, adult (16 years and older) and junior (15 years and under), and two awards per class. Each class had an award for most pounds and largest fish. No minimum size restrictions were placed on the fish.

	<u>Most Pounds</u>	<u>Largest Fish</u>
<u>Adult</u>	\$1500.00	\$1000.00
<u>Junior</u>	\$ 5 0 0 . 0 0	\$250.00

Merchandise prizes were awarded to derby participants who had traveled the longest distance, who were the most sunburned etc. In addition, **all** registered contestants were eligible for merchandise prizes awarded by drawing at the end of the derby.

Merchandise prizes included an air compressor, fish smoker, fishing tackle, dog food, and gift certificates at various businesses including vehicle upholstery, vehicle tops, marine supply, and wedding supply.

Publicity

Publicity for the derby was managed through several channels. A letter was sent to all bass organizations in the region. Fliers were distributed at regional sportsman 's shows. Tapes were sent to Washington and Oregon radio stations for public service announcement spots. News items were placed in a sports newsletter. Signs were placed along Highway 90 at Vantage **and** across the reservoir near Sundown Estates. Of the media used to advertise the derby, WGP members felt that the most effective were the highway signs.

Financing

The derby was financed through private donations. Businesses in the city of Vantage provided a funding base of \$4500, of which \$3350 was used for cash prizes and the remainder used for advertising. Various Washington state businesses provided merchandise. WGP members volunteered time to organize and conduct the derby.

Legal Requirements

Derby organizers were required to apply to the Washington Department of Wildlife (**WDW**) for a group fishing permit. Two permits, each allowing the participation of 250 fishermen, were purchased from WDW. Permits cost \$20 each. Permits were accompanied with detailed WDW rules applying to contests.

DERBY CONDUCT AND RESULTS

Participants

Derby participants came from 36 towns and cities in Washington, Oregon, and **Idaho** (Figure 1). Twenty-six percent of the registrants listed **Ellensburg**, Washington as a home address. A rough estimate of age distribution of participants made by observation at the weighing-in site was as follows:

	<u>Children</u>	<u>Young Adults</u>	<u>Mid-Age</u>	<u>S e n i o r s</u>
<u>Day</u>	14%	20%	43%	23%
<u>Day</u>	11%	25%	53%	11%

Derby Conduct

Two launch sites were available for derby participants: at Vantage and across the reservoir at Sundown Estates. A single weigh-in site was situated at an unused gas station near the Vantage boat launch site. Fourteen WGP members were on hand during the derby, although not all actively employed in derby conduct. Personnel requirements for this derby included people for general coordination, registration, public contact, weigh-in recording, and the awarding of prizes.

Bait and Lures

Several different bait and lures were used by derby participants. These included worms, leeches, corn maggots, bass plugs, spinners, crankbait, shad rap, and a variety of other lures. Many of those fishing experimented with a range of lures and bait.

On the first day of the derby, 43 of the 88 anglers returning to the weigh-in site were surveyed. Most participants questioned said they had used live bait. On the second day of the derby, 42 out of the 47 anglers returning to the weigh-in site were surveyed. By the second day of the derby the majority of the 42 anglers questioned were using live bait, and the number using lures alone had declined.

<u>Using:</u>	<u>Live Bait</u>	<u>Lures</u>	<u>Both Bait and Lures</u>
<u>Day 1</u>	37%	45%	18%
<u>Day 2</u>	55%	22%	23%

Fishing Effort

At least 557 angler hours were applied to fishing for northern squawfish during the two-day derby. Angler hours were not registered for those fishermen who did not report back to the weigh-in station on either or both derby days. Fishermen who did not land any catch may have failed to report in. Fishing effort was distributed throughout the reservoir. On the second day of the derby, participants were asked where in the reservoir they had been fishing: 63% had fished up reservoir (north of the Vantage boat ramp), 6% had fished down reservoir (south of the Vantage boat ramp), 18% had fished both down and up the reservoir, and 13% had fished across the reservoir (east of the boat ramp.)

Pounds Landed

A total of 848 lbs. of northern squawfish were landed during the derby. The catch was about evenly divided between the two days; 40952 lbs. were landed the first day and

438.48 lbs. were landed the second day. Fish weight (of those weighed individually) averaged .91 lb. the first day and .94 lb. the second day. The biggest fish landed during the derby was 4.54 lbs. (Figure 2).

The distribution of individual angler's catch has the skewed form typical of fishery landings; a small number of fishermen have large catches and a large number of fishermen have small catches (Figure 3). Approximately 50% of the derby landings were caught by 20% of the fishermen.

Number of Squawfish Landed

A total of 967 northern squawfish were removed during the derby. This was lower than the expected number of removals, and lower than catch rates at this reservoir in previous years would suggest as a normal return to the level of fishing effort applied during the derby. Four hundred forty-five northern squawfish were removed the first day, an average of 5.06 fish per angler weighing in. Five hundred twenty-two squawfish were removed the second day, an average of 11.11 per angler weighing in.

Catch Per Unit Effort

Catch per unit effort (CPUE), expressed in number of northern squawfish per angler hour, was 1.27 fish per hour for the first derby day, and 1.86 fish per hour for the second. Expressed in pounds of fish per angler hour, CPUE was 1.28 lbs. per hour for day 1, and 1.86 lbs. per hour for day 2.

Incidental Catch

Derby participants were asked about incidental catch when they weighed in. Very few fishermen reported any incidental catch. Over the course of the derby five reports were made of catching steelhead, trout, carp, juvenile salmon and smallmouth bass.

Disposition of Catch

Prior to the derby, organizers approached a rendering company in Seattle to offer the squawfish catch for use in pet food production. Conditions imposed by the company (fish delivered iced or frozen, plus payment of a processing charge) for receiving the squawfish were too restrictive for this derby. The disposition chosen as an alternative was to provide the squawfish to a local farmer for use as fertilizer.

Biological Sampling

A sample of total catch was weighed and measured. On **July 21**, 222 squawfish were weighed and measured, 49.9% of the 445 caught that day. The first 118 measurements were taken of every fish brought in. The next 104 measurements were taken from a sample of total catch. The sampling method used was to take every fourth bag (each individual's catch was placed in a garbage bag) and measure all fish in the bag. All fish were counted. Average weight of measured squawfish on Day 1 was **.902 lbs.** Average length was **317.95 mm.**

Fifty-one fish were measured on **July 22**, 9.8% of the 522 caught that day. These fish were the first fish brought in and were delivered before the end of the derby. Most fishermen reported in to the weigh-in station at the last minutes of the derby and it became impossible to conduct weighing and measuring at the same time as counting fish and interviewing fishermen. There was no opportunity to weigh and measure fish after the end of the derby as there had been the first day. Average weight of squawfish measured on Day 2 was **.938 lbs.** Average length of Day 2 fish was **326.49 mm.**

The weight and length distributions of sampled squawfish are presented in Figures 4, 5 and 6. Figure 7 **illustrates** the weight-length relationship of the sampled squawfish.

Discussion

The derby was not completely successful in terms of meeting the stated objective of removing large quantities of squawfish **from** the Wanapum Pool. **Total** removals were lower than expected. Several participants who had previously caught large numbers of **squawfish** incidental to other fishing commented on their low success rates during the derby. Catch per unit effort was unexpectedly low. Actual catch per unit effort would be lower than the calculated CPUE of 1.28-1.86 **lbs.** per angler hour, since it is fair to assume that fishermen not reporting in at the weigh-in site had applied fishing effort to squawfish which had resulted in low or zero catches.

The number of derby participants, although lower than desired, would probably have been adequate to effectuate a much larger number of removals under different catching conditions.

Derby organizers still consider derby fishing to be the most promising approach to the control of northern squawfish populations in the Wanapum pool. A second derby at this site is planned for next year.

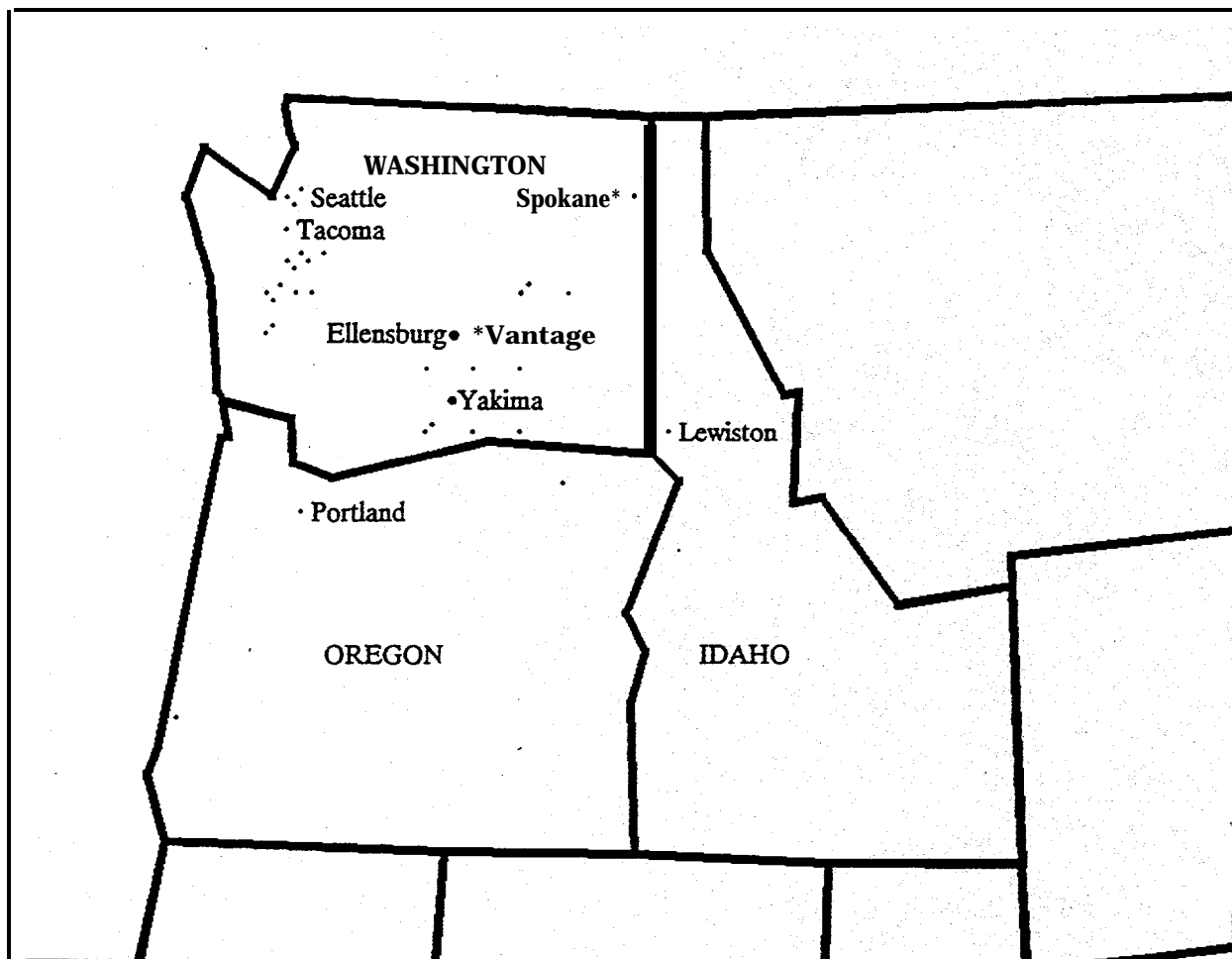


FIGURE 1. RESIDENCE OF NORTHERN SQUAWFISH DERBY PARTICIPANTS

Size of dot indicates number of participants from each site: small dot = 1-3, medium dot = 4-7, large dot = 27.

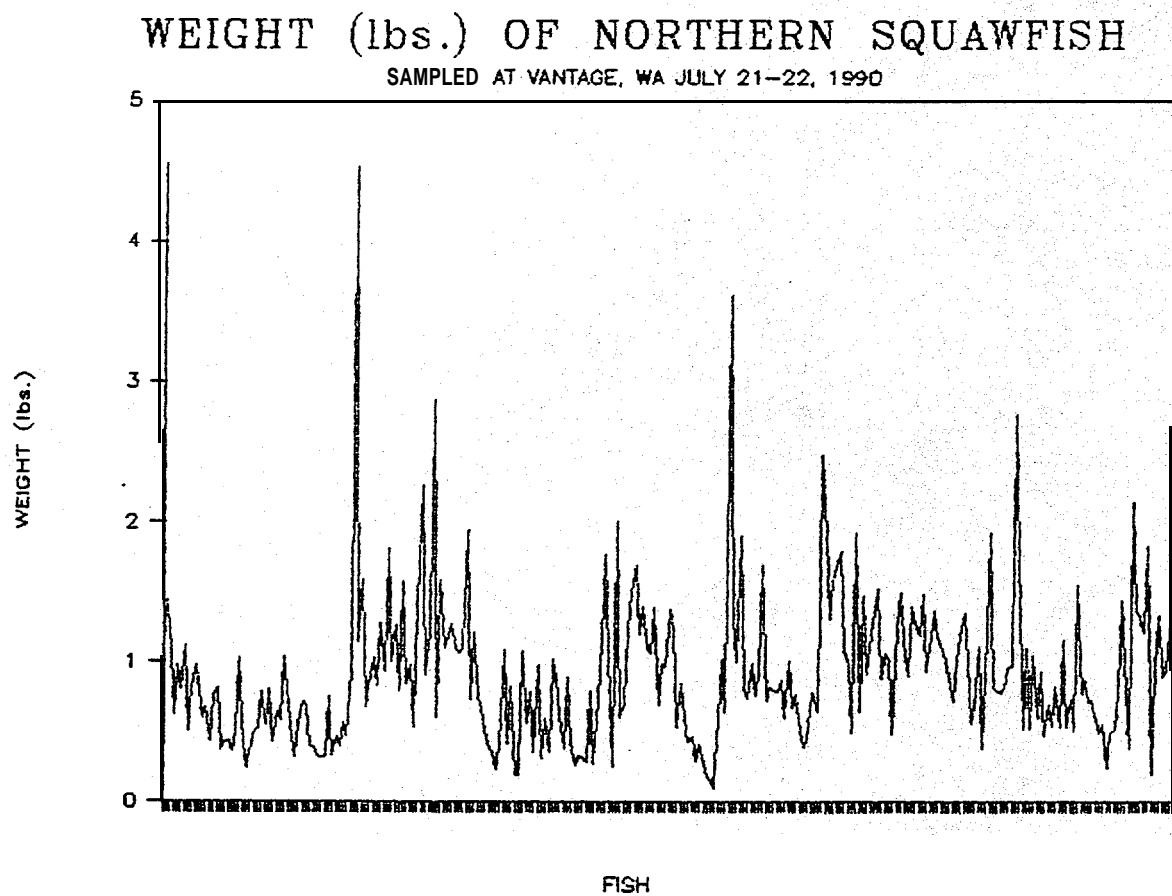


FIGURE 2. WEIGHT OF INDIVIDUAL NORTHERN SQUAWFISH, BY ORDER SAMPLED (N = 273)

CATCH DISTRIBUTION OF N. SQUAWFISH
VANTAGE, WA., JULY 21-22, 1990

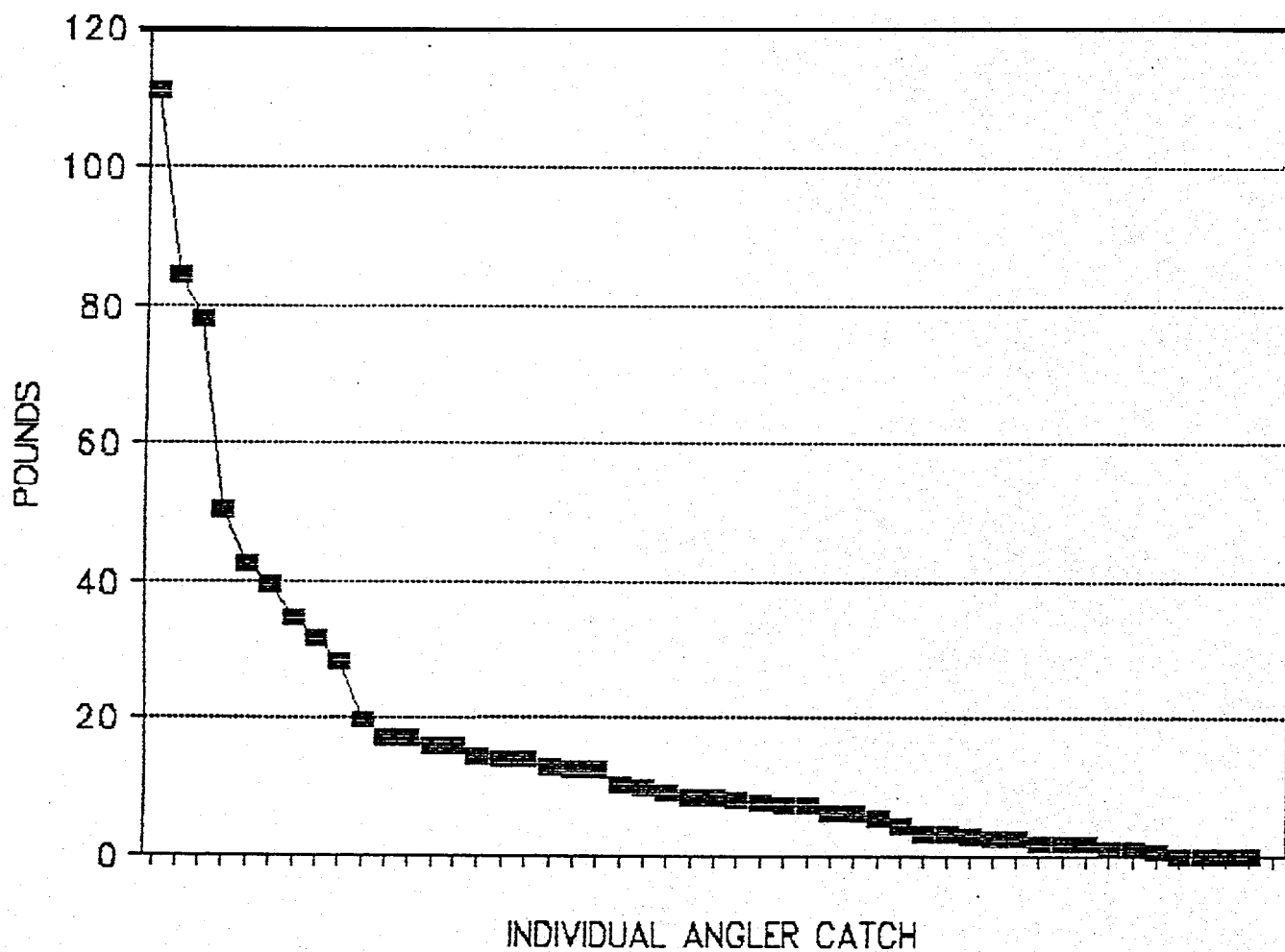


FIGURE 3. POUNDS LANDED OF NORTHERN SQUAWFISH BY INDIVIDUAL ANGLER

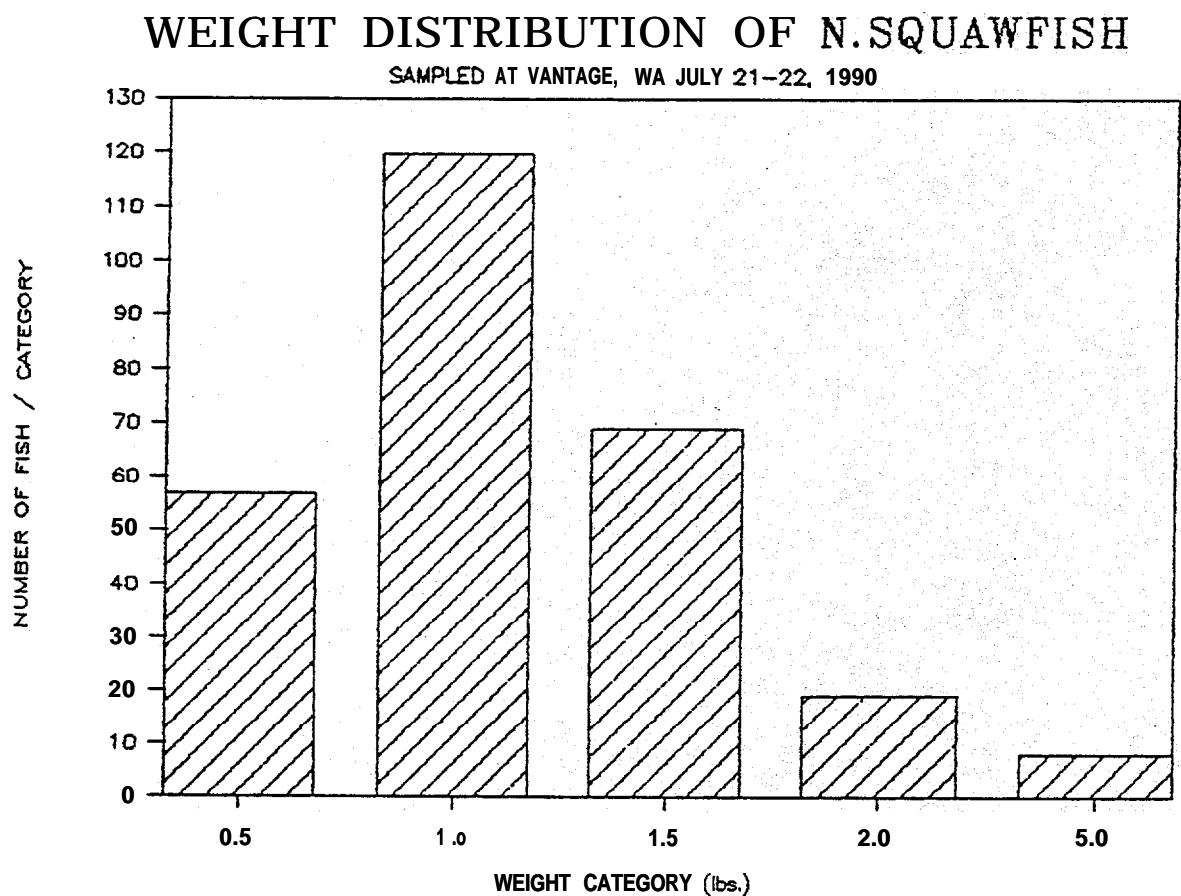


FIGURE 4. WEIGHT-FREQUENCY DISTRIBUTION OF SAMPLED NORTHERN SQUAWFISH (N=273)

LENGTH (mm) OF NORTHERN SQUAWFISH

SAMPLED AT VANTAGE, WA JULY 21-22, 1990

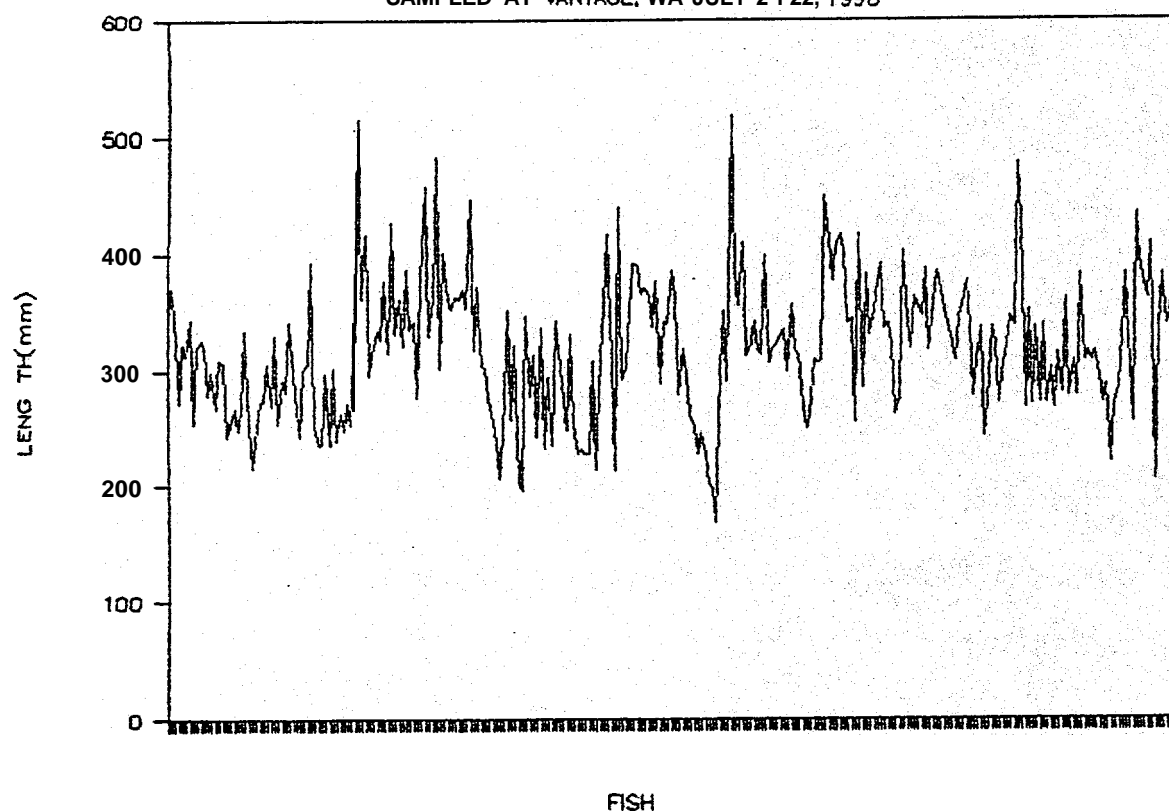


FIGURE 5. LENGTHS OF NORTHERN SQUAWFISH, BY ORDER SAMPLED (N=273)

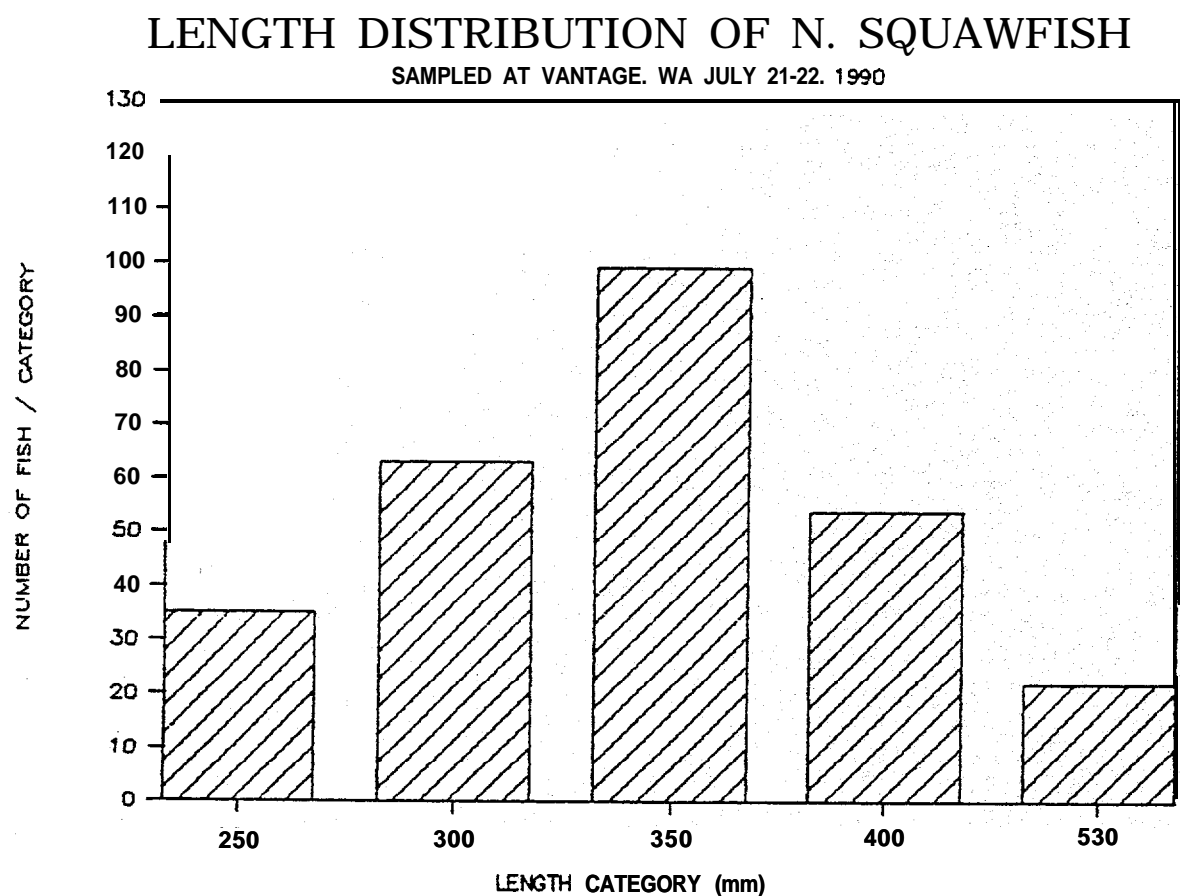


FIGURE 6. LENGTH-FREQUENCY DISTRIBUTION OF SAMPLED NORTHERN SQUAWFISH (N=273)

WEIGHT/LENGTH OF NORTHERN SQUAWFISH

SAMPLED AT VANTAGE, WA JULY 21-22, 1990

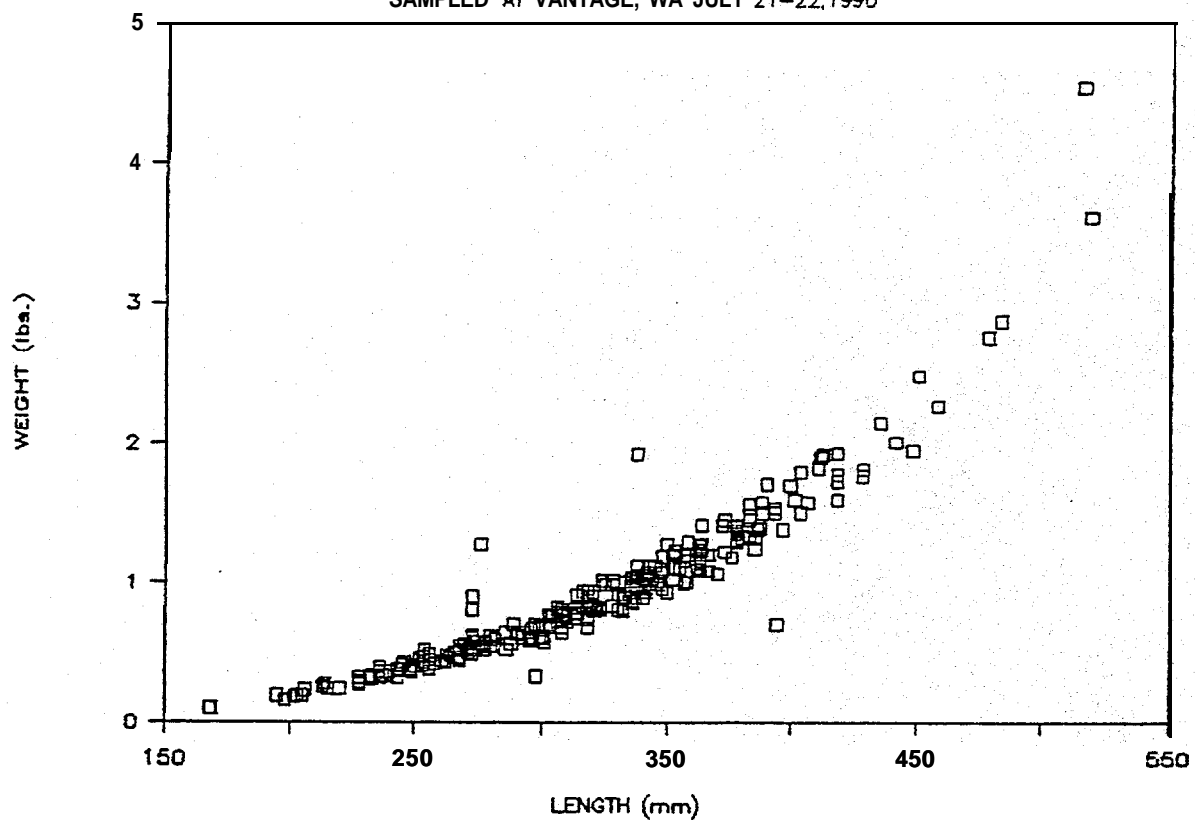


FIGURE 7. WEIGHT-LENGTH RELATION OF SAMPLED NORTHERN SQUAWFISH (N=273)

APPENDIX B-7.

Report on the Collection and Delivery System for Northern Squawfish

Development of the Northern Squawfish

Collection and Delivery System

Final Report

Jon Pampush

May 23, 1991

INTRODUCTION

As part of the Columbia River Northern Squawfish predator control study, a program was developed to collect, store, transport and deliver the squawfish carcasses to end users. **Squawfish** collected by dam angling, **longline**, and sport bounty were put into plastic bags and then into chest freezers located near the removal sites and allowed to accumulate until the freezers became **full**. At this point, the carcasses were picked up and pitched into commercial fishing totes on a flatbed truck and delivered to one of three freezer facilities for temporary storage. When an end user wanted to process **squawfish**, the volume they requested or was available at the time was retrieved from a freezer **facility** and delivered to them. Afterward, the end users were requested to complete a questionnaire that provided information about the products they produced.

METHODS

Because this was the first year of the squawfish removal program that was expected to produce large numbers of fish, a transport system had to be developed that could handle the anticipated volume. This system had to accomplish the following tasks:

1. Purchase chest freezers and deliver them to **appropriate** locations.
2. Purchase commercial fishing totes and any other equipment necessary for **handling** the carcasses.
3. Rent vehicles needed for transporting the carcasses.
4. Arrange and purchase freezer storage space at convenient locations.
5. Pick up squawfish and deliver to **freezer** facilities.
6. Arrange and provide deliveries to end users.
7. At the end of the season, retrieve **all** freezers, totes and other equipment and provide storage.

TRANSPORTATION AND HANDLING

Preparation for the carcass handling program occurred between May 3 and June 4. During this period the arrangements were made for equipment purchases, vehicle rental, and cold storage space. By June 5 all the chest freezers were in place and prepared to handle the squawfish carcasses. The following is a list of the freezer locations and users:

<u>Location</u>	<u>no</u>	<u>User</u>
Bonneville Dam	2	dam anglers
The Dalles Dam	1	dam anglers
Biggs Field Station	1	dam anglers, sport bounty
John Day Dam	1	dam anglers
Arlington Grain Elevator	1	longline observers
Irrigon Marina	1	longline observers
McNary Dam	1	dam anglers
Hermiston Field Station	2	dam anglers, sport bounty, longline observers

Two vehicles were rented from the OSU Motor Pool for the program, a 1/2 ton flatbed truck and a 1/2 ton pickup truck. Much of the handling and transportation involved small volumes (two totes or less) which justified the need for the relatively inexpensive to operate pickup truck (about 2/3 the operating cost of the 1/2 ton). **Larger** deliveries to the commercial cold storage facilities (Americold in Wallula WA and Northwest Ice and Cold Storage in Portland, OR) and to end users were handled by the 1/2 ton flatbed. Some deliveries were made using a one ton truck because the 1/2 ton was being repaired.

Fish pickups and cold storage deliveries occurred between May 24 and September 18. A total Volume of 415 totes was collected during this period with an estimated weight of 9500 kgs (weight estimates are based on the cold storage rate of 225 kgs/tote). As part of the cold storage network, the Oregon Dept. of Fish and Wildlife Irrigon Fish Hatchery provided temporary freezer space for totes that were **enroute** to the commercial facilities. The following was the typical pickup and delivery itinerary:

1. **Arrive** Bonneville Dam, load two empty totes onto the pickup truck, and empty the carcasses from the **freezers** into the totes (totes were stored on Bonneville dam).
2. Stop at other freezers between **Bonneville** and Hermiston and pick up more **fish** until the two totes were full.
3. Deliver the two full totes to the Irrigon Fish Hatchery freezer and spend the night in **Umatilla**.
4. Drive to the **Hermiston** field station, pick up the 1 1/2 ton truck (parked at the field station), and empty the field station freezers.
5. Pick up the two totes stored overnight at Irrigon Hatchery and pick up the fish **from** the **McNary** Dam freezer.
6. Deliver the full totes to Americold cold storage facility in Wallula WA
7. As needed, pick up full totes from Amexicold and deliver to end users.

Naturally, variations to the above schedule occurred;
the following **is the** delivery schedule to the cold storage **facilities**:

<u>Facility</u>	<u>Date</u>	<u>No Totes</u>	<u>Weight (est)</u>
Americold	July	39	2045 kgs
Americold	July 17	4	910 kgs
Americold	Aug 2	6	1365 kgs
Northwest	Aug 10	4	910 kgs
Americold	Aug 15	4	910 kgs
Americold	Aug 28	5	1135 kgs
Americold	Sept 5	<u>4</u>	<u>910 kgs</u>
		36	8185 kgs

A small OSU Motor Pool trailer was provided for the transportation of sport-bounty fish to the field station chest freezers. However, it was never used because the sport-bounty never produced the volume necessary to justify it.

Four end users participated in the program; Inland Pacific Fisheries (IPF), Bioproducts (**BIO**), Astoria Seafood Lab (ASL), and Roy **Gilmore** (commercial fish buyer and bait dealer). These processors or individuals received squawfish deliveries and experimented with various uses in an attempt to identify potentially marketable products. Below is the **squawfish** delivery schedule and end use:

<u>End User</u>	<u>Location</u>	<u>Date</u>	<u>Volume</u>	<u>Product</u>
Gilmore	Dallesport, WA	July 12	27 kgs	crab bait
IPF	Payette, ID	Aug 8	1820 kgs	organic fertilizer
ASL*	Astoria, OR	Aug 23	132 kgs	frozen deboned fish
BIO	Warrenton, OR	Aug 23	910 kgs	fish food
IPF	Payette, ID	Sept 18	1137 kgs	organic fertilizer

***fresh** fish delivery

132 kgs. of fresh-iced squawfish were delivered to the Astoria Seafood Laboratory on August 23. A boneless **ground frozen** product was produced for distribution to Asian Markets in Portland and Salem in November.

As of September 20, there remain 20 totes (4550 kgs) at Americold cold storage in Nampa, Idaho (transferred from the **Wallula** facility by Simplot Transportation): These carcasses will be processed by Inland Pacific Fisheries in October or early November and will probably become organic fertilizer.

COLLECTION, STORAGE, AND DELIVERY EXPENSES

The following is a breakdown of expenses for the field season through October 25:

Equipment Purchases

<u>Item</u>	<u>No</u>	<u>Unit Cost</u>	<u>t a l C o s t</u>
23 cubic foot Kenmore chest freezers	10	381.00	3810.00
21 cubic foot "Tra-Totes"	28	165.00	4620.00
2 cubic foot totes	10	12.70	127.00
Miscellaneous supplies			<u>225.00</u>
			8782.00

Vehicle Rental (from OSU Motor Pool)

<u>Vehicle</u>	<u>Rate</u>	<u>Total Miles</u>	<u>Total Cost</u>
1.5 ton flatbed	.37/mile, 276.00/Mo.	3832	2591.00
1/2 ton P/U	.25/mile, 188.00/Mo.	7844	2933.00
1 ton flatbed	.26/mile, 15.16/day	2350	838.00
Utility trailer	58.00/Mo. (4 Mo.)	-	<u>232.00</u>
		14026	6594.00

Other Expenses

Per Diem	1228.00
Simplot Transfer (Simplot Transportation shipped 20 totes from Americold, Walulla to Americold, Nampa)	<u>400.00</u>
	1928.00

Cold Storage Rental

<u>Company</u>	<u>Volume Handled</u>	<u>Total Cost</u>
ODFW Irrigon Hatchery	3865 kgs	no charge
Northwestern Ice and Cold	910 kgs	75.00
Americold Corporation	1810 12955 kgs	<u>624.00</u> 699.00

DISCUSSION

TRANSPORTATION AND HANDLING ANALYSIS

Most of the fish handling and transportation occurred between Bonneville dam and **Wallula**, Washington; a distance of about 170 miles. However, the furthest points of the project area are over 400 miles apart (**Payette**, ID to Astoria, OR). To date the project has logged over 14,000 vehicle miles.

Currently, the money spent for the carcass handling project is divided fairly evenly between equipment purchases and transportation costs (**\$8,782.00** vs. **\$6,594.00**). However, since most of the necessary equipment has been purchased (at least for the 1990 harvest volume), transportation of the carcasses will probably consume most of the time and money in the future (cold storage is a minor expense; \$699.00 to date).

It **appears** the most cost efficient strategy for transporting the carcasses is to allow them to accumulate in the freezers until a large volume can be picked up at one time. For example, the cost of transporting a full load (1820 kgs) with the 1 1/2 ton truck is about **.22/kg/1000** miles. This cost could be reduced if a larger volume was handled, say 8000 kgs. However, because freezer space was limited and freezers filled up at unpredictable rates, many small volume pickups had to be made (creating the need for the 1/2 ton pickup). Consequently, the actual average transportation cost was about **.60/kg/1000** miles. The following factors tended to limit the volume that could be handled during a single trip:

1. The freezers had to be emptied frequently because the freezer space available to the fish harvesters was limited.
2. Freezers become full at irregular rates, making it necessary to make frequent small volume pickups.

3. The maximum capacity of the available vehicle was 4,000 lbs.
4. Without a lift truck and other equipment, one person cannot handle 8000 kgs. in a day.
5. Fish picked up on a given day had to be delivered to a freezer facility that night (to prevent thawing); this time limit prevented large pickups over long **distances**.

The fresh fish delivery to the Astoria seafood Lab on August 23 was made with the use of the 1 1/2 ton truck because it was also carrying a 900 kg frozen delivery to Bioproducts. As a result, the cost of this delivery does not reflect the cost of handling fresh fish exclusively. Using a pickup truck, fresh deliveries over this distance (**McNary** Dam to Astoria/ 290 miles) could be made for about **.33/kg (1.10/kg/1000 miles)**. Carrying larger volumes could further reduce the cost, but it would be difficult for the anglers to catch and hold much more than 250-500 kgs of live fish for a single delivery.

Problems Encountered

For the most part, the transportation program went fairly well aside from the previously mentioned limitations. However, **several** problems did arise that should be corrected if the project was to expand or otherwise catch more fish.

Height of the Truck Bed - The 1 1/2 ton used for the project had a ground to bed height about 8 inches shorter than the standard loading dock height found at the **freezer** facilities. Although this difference seems minor, it often created considerable **difficulty** when loading or unloading (many loading bays do not have adjustable ramps).

Filling Totes on the Truck - The process of emptying the freezers into the totes was completely **manual**. This often required one to remove about 35-40 kgs **from** a freezer into a hand tote, **lift** the tote onto the truck bed, climb onto the bed, then empty the hand tote into a large tote stacked on another large tote. Obviously, this operation can be very time consuming if one is emptying two **freezers** at a single location (600-650 kgs).

Access to Freezers - Many of the freezers were not located in an area where the truck could be parked, adding more time to the manual loading procedure.

Thawing - The temperature in the project area often exceeded 100 degrees F during July, August, and early September. The hot weather often made it necessary to make extras trips to the freezer facilities. **Also**, when a large number of fish were put into the chest **freezers** at one time, they often froze very slowly or not at all.

Recommendations

Assuming the project will catch as many or more fish in the future, I would recommend a larger truck with a standard dock height bed and a hydraulic lift. In addition to the larger vehicle, a pallet jack would be needed. With these two items, one could pallet jack a tote to a chest freezer, fill the tote, then lift the full tote onto the truck. Such a vehicle would correct all of the loading and handling problems including the chest freezer location situation (considering access for everyone who used them, the freezers were well situated and other locations are probably unavailable anyway).

In the areas that tend to collect the most fish (Bonneville Dam, McNary Dam, John Day sport bounty), it may be advisable to install additional freezers for two reasons. First, to provide greater space to allow for larger pickups, and second, to eliminate the slow freezing situation during hot weather. Additional freezers may be essential anyway if the project should catch a greater volume in the future.

If the geographic area and the volume of **fish** harvested should expand greatly in the future, then it may be necessary to have an assistant at times as well as the lift truck. The need for an assistant probably could not be determined until a few runs are made using the lift truck.

Because no one can do anything about hot weather, there may be some use for a few insulated totes in the future. These could be used in conjunction with the chest freezers if an unusually large number of fish is caught and a pickup could **not** be made immediately. Already frozen **fish** could be pitched from a chest freezer into an insulated tote to make room for unfrozen fish.

CONCLUSION

Hopefully, the products tested by the end users in 1990 will show some economic promise in the future. Currently, however, nothing has been produced that is valuable enough to get end users financially interested in the transportation of the carcasses (at least at the current, rate of harvest). This situation could change if the harvest is increased considerably or a relatively valuable product is identified.

APPENDIX B-8.

characteristics of Fish Processing Techniques with Potential for Northern Squawfish

Characteristics of Fish Processing Techniques and their
Potential for Northern Squawfish

Jon Pampush

Department of Agricultural and Resource Economics
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February 6, 1991

Economic, Social and Legal Feasibility of Commercial,
Sport and Bounty Fisheries on Northern Squawfish

Project 90-077

Cooperators

Oregon Department of Fish and Wildlife
Oregon State University
University of Washington

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INTRODUCTION

This report is intended to investigate the opportunity for "small scale" processing of northern squawfish harvested during the Columbia River Northern Squawfish Predator Control Study. In 1990, the harvest program yielded about 18,000 kgs of northern squawfish, and it appears the 1991 program will be expanded considerably. The expanded program could potentially produce two to three times the 1990 harvest. Although 40,000 - 60,000 kgs of fish is a considerable amount, this volume is trivial compared to what many commercial processors must consume to compete in fish processing markets (a surimi line can process this volume in one day). With this in mind, this report was written with an emphasis on small, low cost, low technology processing opportunities.

Little is known about the appropriateness of northern squawfish for many of the processes described in this report. Some of the processing options discussed may not work using squawfish. Among those who have experimented with northern squawfish, there is a general consensus that these fish are very bony, have a good flavor, and are not oily (this contrasts to the commonly held belief that "trash fish" are oily). Some information from processors who have dealt with northern squawfish is available and is included in this report.

PROCESSING METHODS

MINCED FISH

Minced fish is a relatively simple technology that may be appropriate for processing northern squawfish. Mincing requires a deboning machine that works by forcing the meat through a screen or other perforated barrier while leaving the bones behind. The final product is boneless "patty meat" suitable for fish balls, fish cakes, and other minced products.

Processing Equipment

Deboning (mincing) machines are fairly small and relatively inexpensive. The Clauden model 200 occupies a space of about one cubic meter, can process 600 kgs/hr, and costs about \$16,000. Clauden also offers the 805, an easier to clean unit designed to produce a high quality product. This machine is about the same size as the 200 and costs about \$20,000 (Clauden deboner

literature). Beehive Machinery, Inc. offers the very compact, low heat RSTC-02 food processing machine. This unit can process about 230 kgs/hr and costs about \$22,000 (Beehive deboner literature). These machines alone require little more than electric power and a small work area, but a freezer and other accessory equipment would be necessary to package and preserve the product.

Operating Requirements

The small deboning machines offered by Clauden and Beehive need only one operator, but some labor is required to prepare the whole fish for mincing if a quality, food grade product is desired. The fish should be planked (heads, guts, and backbones removed) to reduce the amount of blood and other undesirable material in the final mince (D. Crawford 1990). The labor required for preparation would depend on the volume being processed and the desired quality of the final product.

Automating the preparation phase is not practical at this scale because the commercially available machines are designed for very large scale operations. Baader, Inc. manufactures a line of these machines including a header at \$16,000 and a gutter at \$24,000. These units are designed to process 50 or more fish/minute; this rate would easily overwhelm a small mincer (Clauden 1990).

Equipment Availability

Deboning machines are readily available from Clauden Inc. of Seattle Washington, and from Beehive Machinery of Sandy, Utah.

Product Suitability for Northern Squawfish

In July, 1990, the Astoria Seafood Laboratory in Astoria, Oregon minced about 120 kgs of fresh squawfish using a Clauden deboner. The final product was test marketed among the local Asian community and received favorable responses in terms of flavor, texture, etc. Hopkins (undated) performed consumer tests with whole northern squawfish and received generally favorable responses (the bones were the only consistent complaint), I have eaten minced squawfish from this batch and found the taste to be bland but 'good,

Minced fish has two inherent problems associated with freezing: First, if the fish is frozen and then thawed before deboning, the resulting product is usually of poorer quality compared to mince

made from fresh fish (D. Crawford 1990). It is preferable to mince fresh squawfish, but the transportation costs associated with daily deliveries will be very high if landing sites are widely dispersed. Second, the mincing process tends to rupture cells, causing a number of problems related to texture and freezer life (Sorenson 1980). However, I have eaten minced squawfish that had been frozen for 5 months and it appeared to be in very good condition. In general, minced northern squawfish seems to be a high quality, very palatable protein source. Research conducted under the 1991 "Feasibility" project will include tests on alternative mincing methods and. on shelf life.

Summary of equipment information (minced fish):

Equipment.....	Clauden 200	Clauden 805	Beehive RSTC-02
Size (m).....	1 x 1 x 1	1 x .9 x .9	1.2 x 1.5 x .8
Processing Capacity.....	600 kgs/hr	300 kgs/hr	230 kgs/hr
Power Requirements.....	N/A	1.5 kw motor	3 or 5 hp electric motor
Labor Requirements	1 operator*	1 operator*	1 operator*
Est. 1990 Purchase price...	\$16,000	\$20,000	\$22,000

*does not include preparation labor

SMOKING

Smoking is a processing alternative that ranges in scale from the "backyard" smokehouse to 20,000 kg/day commercial operations. Smoked fish is produced by soaking the meat in a brine solution and then exposing the meat to a "smokey" environment. One can smoke fish under low or high heat conditions and produce different types of products.

Processing Equipment

Smokers can be manufactured at home with a multitude of common materials including plywood, sheetmetal, and 55 gallon drums.' In developing countries, homemade, improvised smokehouses are often used to preserve fish because refrigeration is often unavailable.

Ken Hildebrand, Extension Seafood Specialist at the Hatfield Marine Science Center in Newport, Oregon has designed various low-cost smokehouses that are intended for the small scale smoker. Some of these units can be manufactured for about \$150 - \$200.

On a commercial scale, smokers are available in Oregon from Enviropak in Clackamas, Oregon. Their smallest model, the 150, is about 1.3 cubic meters, can process about 18 kgs/5 hrs, and costs from \$8,000-\$11,000 depending on instrumentation. These units are in use extensively in the Northwest in delis, retail meat outlets, and seafood outlets (Martini 1991).

Operating Requirements

Commercial smokers require electricity, various types of wood chips, and a brine solution, all of which are available at fairly low cost (The electricity cost for the Enviropak 150 is about 16 cents per 5 hours). The operation of a smoker is not labor intensive, but the fish preparation may be.

Product Suitability for Northern Squawfish

Some anecdotal evidence exists on sport fisherman smoking squawfish, but no information about commercial squawfish smoking is available. It has been suggested, however, that two potential problems may be encountered. First, since squawfish is so bony, it probably would not be a desirable commercial product. Second, the low oil content of the flesh may cause the finished product to be "powdery" (Martini, 1991).

Smoking has another attribute that may or may not be considered desirable; the processing time is relatively slow and therefore fairly compatible with the squawfish harvest rate. Running continuously, an Enviropak 150 would require about 3 or 4 months to process the 1990 catch. Many of the other options discussed in this report could do the same work in a matter of days or weeks.,

Equipment Availability

An Enviropak 150 can be delivered in about four weeks; larger models are also available. Information about the small smokehouse designs is available from Ken Hildebrand at the Marine Science Center.

Summary of equipment information (smoking):

Equipment	Enviropak 150	Small "homemade" models
Size (m)	1.2 x 1.2 x 1.5	Information available
Processing		from Ken Hildebrand,
Capacity	40 kgs/5 hrs	Hatfield Marine Science
		Center, Newport, OR
Power		
Requirements	4.5 kw	
Labor		
Requirements	variable	
Est. 1990		
Purchase Price	\$8,000 - \$11,000	

FILLETS

A fillet is the portion of a fish that is removed by slicing the meat away from the backbone and ribs. Filleting is usually done with relatively high value fish (salmon, halibut, etc.) and the product is sold in markets and restaurants.

Processing Equipment

On a scale suitable for available quantities of northern squawfish, filleting would be performed manually at a fillet table. Fillet tables are stainless steel, self-draining, and usually custom made to accommodate specific processing needs. Mechanical fillet machines are expensive and are intended for very large scale production (Crawford 1990).

Processing Requirements

Manual filleting is very labor intensive because the fish are processed one at a time by filleters who work under piecemeal arrangements. Consequently, most filleted species have a high market value. A fillet line also requires rinse water and a means of waste disposal. An Oregon coast seafood processor has estimated that a high production six station fillet line can be purchased for about \$10,000, and a small, low technology operation can be assembled for about \$1,500.

Equipment Availability

A fillet table is usually custom manufactured after individual processing requirements are assessed.

Product Suitability for Northern Squawfish

Despite its acceptable flavor, northern squawfish is probably not suitable for commercial filleting since the meat is very bony. Bony fish require labor-intensive processing which creates high labor costs. At the present time no market for northern squawfish shows the potential to cover these processing costs.

Summary of equipment information (filleting):

Equipment	fillet table (custom made), knives, cutting boards
Size	variable, depending on volume
Processing Capacity	variable. depending on labor input
Power Requirements	no direct power input required
Labor Requirements	variable. but labor intensive-even on a small scale
Est. 1990 Purchase Price	\$1,500 - \$ 10,000

DRY EXTRUSION

Dry extrusion is a process that produces animal feed and other protein products from animal and vegetable material (using fish as a raw material, the end product is basically fish meal; commercial fish meal production will be discussed later). Dry extrusion cooks the raw material by utilizing high pressure heat rather than steam cookers. The pressure is generated by an impeller, driven by a powerful electric motor, that forces the material through a narrow channel. Dry extruders produce virtually no waste, and can utilize almost any protein source (whole chickens with feathers, egg shells, fish scraps, etc.).

Processing Equipment

Dry extruders are fairly compact units and are available from Insta-Pro of Des Moines, Iowa. The model 600 is fairly small (2 cubic meters) weighs 600 kgs, and can process 200-300 kgs/hr. This unit costs about \$10,000 and can be fitted with a supplemental outdrive die cutter at \$4,200 that can produce pelletized feed (Insta-pro literature).

Operating Requirements

The dry extrusion process dispenses with many of the devices and resources that a commercial fish meal plant requires, but the model 600 does require electric current capable of powering the 75 hp electric motor. The machine can be run by one operator, but for safety purposes, it is recommended that two operators be present.

Equipment Availability

Dry extruders are available upon order from Insta-pro of Des Moines, Iowa.

Product Suitability for Northern Squawfish

Dry extruders are best suited for producing a product that is to be consumed locally (catfish farms, small feedlots, etc.). It must be noted that high water content raw material (fish) must be mixed with a dry vegetable product (soybean) for the process to work. Anything over 75% water content probably has to be pressed or centrifuged before being extruded. This consideration may

render squawfish unsuitable for dry extrusion unless it is mixed with a vegetable material. However, Insta-pro has successfully processed some types of whole fish using dry extrusion.

Summary of equipment information (dry extrusion):

'EquipmentInsta-Pr o Model 600 Dry Extruder*
Size (m)2 x 1.8 x 2
Processing Capacity.....20 0 - 300 kgs/hr
Power Requirements.....220/440V 3 phase 176/87 amps, (75 hp)
Labor Requirements.....1 or 2 operators
Est. 1990 Purchase Price....\$10,000, (+ \$4,200 for die cutter)

*the 600 is the smallest Insta-Pro model

COMPOSTING

Fish cornposting is an experimental technology that was developed to deal with fish processing waste in an economically and environmentally sound manner. Fish compost is produced by piling together fish or fish waste and peat and allowing bacteria to decompose the fish. This technology is very simple, low cost, and the finished compost can be sold to home gardeners and highway departments (Goldhor 1988).

Processing Equipment

A fish compost pile requires a tarp (rain protection), netting (wind protection), about 20 m PVC sewer pipe (ventilation), and a variable quantity of peat or other decomposition substrate. There is no mechanical equipment involved in the cornposting process.

Operating requirements

Fish compost piles have no direct operating costs other than the labor required to build the compost piles, monitor the progress

of the decomposition, and bag the finished material. Ideally, the piles should be placed on a gravel surface for air circulation. "Often some trial and error is required to successfully compost a previously untried raw material.

Equipment Availability

Any equipment needed for cornposting can be bought from a hardware store or garden supply dealer. Most peat is harvested in eastern Canada, but it is available in the Northwest for about \$8/bale (4 cubic feet) if it is ordered by the semi-truck load (M. Cameron 1991). Goldhor performed his experiments in the East, so he probably purchased peat at a lower price.

Product Suitability for-Northern Squawfish

Unquestionably, squawfish would make fine compost, but it would probably be a very low value product. Cornposting might be an attractive option if a local need for the enriched material was identified.

SILAGE

Silage is another process intended to reduce or eliminate fish waste problems. Silage differs from cornposting because the decomposition occurs in airtight containers. Also, silage can be sold as animal feed supplement when the market is favorable.

Processing Equipment

Silage requires nothing more than airtight containers (plastic lined boxes, 55 gallon drums, etc.), and a vegetable substrate such as corn stover or peanut hulls (Cook, 1980). The process may also require an acidic additive (vinegar) to maintain a low pH. It should be noted that, like composting, profitable silage production is experimental and subject to variability in the animal feed market.

Processing Requirements

Like cornposting, there are no machines required to produce silage. Labor is required to pack, transfer, and bag the finished product. If vinegar is necessary, the process often loses its cost effectiveness.

Equipment Availability

All equipment is readily available retail or can be salvaged from other operations.

Product Suitability for Northern Squawfish

Squawfish may or may not be suitable for silage. A chemical analysis would be necessary to make this determination.

* * * * *

The remaining options discussed in this report, organic fertilizer, fish meal, and surimi, usually require very large volumes of raw material to produce an economically viable product. Consequently, it is unlikely any of them are suitable processing options as far as the squawfish program is concerned. However, they may have some application if a large volume of supplementary raw material could be identified and harvested cheaply.

ORGANIC FERTILIZER (HYDROLYZING)

Organic Fertilizer from fish is the simplest product among a family of more refined products that begin as "liquid fish." Organic fertilizer is made by grinding, deboning, and liquefying whole fish carcasses or waste from canneries or other fish processors. The resulting slurry is a biologically stable liquid fish protein that is applied to crops as a substitute for chemical fertilizers. None of the liquid fish technologies that I could find can operate economically at the scale anticipated for the northern squawfish removal program, but hydrolyzing appears to offer the smallest scale among them.

Hydrolyzers liquify the ground, strained fish by "digesting" the fish protein using enzymes instead of cooking it with the high heat characteristic of conventional technologies. Organic fertilizer hydrolyzing technology is still economically experimental in the Northwest.

*Processing** Equipment

Hydrolyzing machines are available in the Northwest from Advanced Hydrolyzing Systems in Astoria, Oregon. AHS has built a large, \$175,000 pilot scale unit that is currently operating in Payette,

Idaho, and is owned by Inland Pacific Fisheries. This unit is built on a single platform, is 2x 3x4m, and is capable of processing 400 kgs/hr. An AHS hydrolyzer can be modified to produce more refined products like fish meal and fish oil (Law 1990).

AHS can manufacture a 400 kg/hr unit intended exclusively for the production of organic fertilizer for about \$70,000. They also have a smaller experimental model that may be available for lease on a seasonal basis (does not include steam boiler).

Operating Requirements

These units require at least two operators, and there is considerable work associated with cleaning the machine and packaging the product. The actual labor requirements would depend on the volume being processed. The 400 kg/hr machine is powered by a three phase, 440 v motor, requires 220 kg/hr steam and 70 l/min cooling water.

Equipment Availability

Hydrolyzers are available from Advanced Hydrolyzing Systems of Astoria, Oregon. A production scale model would have to be ordered and probably is not quickly available. The small experimental size unit is located in Astoria and may be readily available.

Product Suitability for Northern Squawfish

Inland Pacific Fisheries has experimented with northern squawfish and concluded that squawfish must be mixed with "oilier" species to run properly. Squawfish alone did not work well in the process.

Summary of equipment information (organic fertilizer-hydrolyzing):

Equipment	AHS pilot unit	AHS exp. Unit
Size (m)	2 x 3 x 4	N/A
Processing Capacity	400 kgs/hr	N/A

Summary of equipment information (organic fertilizer-hydrolyzing):- cont.

Power	3 phase 440 v,	
Requirements	220 kg/hr steam	N/A
Labor	at least 2	
Requirements	operators	2 operators
Est. 1990		negotfable
Purchase Price	\$70,000 (fert. only)	lease

FISH MEAL AND FISH OIL

Fish meal is cooked, homogenized, dehydrated fish protein primarily intended for the manufacture of fish, mink, and animal feeds. Fish meal is probably not a suitable processing option for expected yields of northern squawfish. The smallest commercial plant that I have investigated could process the total 1990 northern squawfish harvest in 3 to 4 days. Most commercial fish meal plants are very large operations located in areas with an abundance of raw material. With the addition of pelletizing equipment, fish meal can be further processed into pelletized fish and animal feed. Fish oil is a by-product of fish meal production and its uses include the production of margarine, paint, and fuel (Alfa-Laval Fish Protein and Fish Oil).

Processing Equipment

Alfa-Laval of San Raphael, California manufactures two fish meal plants that are considered small, the Centrifish plant and the Condec system. Both these units produce fish meal by grinding, cooking, and drying the raw material (usually fish processing wastes). Oil is centrifuged and decanted after the cooking phase. Because of their compact designs, these plants are often installed on processing ships. Despite their small size, these plants can consume considerable amounts of raw material and they are quit expensive to purchase and operate.

The smallest Centrifish plant for which I have found printed information is the 11,000 kg/24 hr unit. This system is about 3x 4x 4 m and weighs 10,000 kgs. The smallest Centrifish system available is a 6,000 kg/24 hr unit. The smallest Condec system is the 23,000 kg/24 hr unit; this plant is clearly beyond the scope of the squawfish program so I will not discuss operating specifics. (Alfa-Laval Centrifish literature).

As I mentioned earlier, the Advanced Hydrolyzing Systems hydrolyzing unit can be upgraded for the production of fish meal and oil. The pilot unit currently in operation runs at a rate comparable to a small Centrifish system, but it has never produced fish meal/oil commercially. In the context of northern squawfish removals, it appears neither of these technologies could produce fish meal economically unless the squawfish could be greatly supplemented by another source of raw material.

Operating Requirements

The 11,000 kg/24 hr Centrifish plant consumes 32-34 kgs fuel/1000 kgs of raw material, 26 kW electric power, and 25-40 l/hr of fresh water. No data on the 6,000 kg/24 hr unit is available, and no labor information is available for any of the Centrifish plants.

The AHS hydrolyzer technical data is discussed in the organic fertilizer section.

Equipment Availability

Conventional fish meal systems are available through a number of manufacturers in the United States. Alfa-Laval is located in San Raphael, California, and AHS in Astoria, Oregon. These systems are fairly complicated and require custom installation and operating consultation.

Product Suitability for Northern Squawfish

Bioproducts of Warrenton, Oregon has experimented with squawfish using conventional fish meal technology and decided the strong odor emitted during processing made it unsuitable for their process. Since Inland Pacific Fisheries has never produced fish meal from squawfish, the fish meal hydrolyzing technology is untested for this species.

Summary of processing Information (fish meal/oil):

Equipment.....Centrifish	AHS pilot unit
Size (m) 3 x 4 x 4	2 x 3 x 4
Processing Capacity.....11,000 kgs/24 hrs*	9,600 kgs/24 hrs

Summary of processing information (fish meal/oil): cont.

Power Requirements	32-34 kgs fuel/1,000 kgs raw mat.; 26 kW electric	3 phase 440 v, 220 kg/hr steam
Labor Requirements.....	N/A	2 operators
Est. 1990 Purchase Price.....	N/A	\$175,000

*also available in 6,000 kg/24 hr model

SURIMI

Surimi is a fish processing technology that is used to manufacture fish and shellfish analogues, mostly imitation crab legs. Most surimi is made in Japan or on Japanese factory processing ships. Alaska pollack is the principal raw material of the Surimi process (Mitchell 1985).

Processing Equipment

On a commercial scale, a conventional surimi operation is a high investment, high technology process requiring a huge resource base. A letter I received from Brian Clauden of Clauden, Inc. (processing machine distributors) details the requirements of a surimi line. "A surimi line includes headers, gutters, filleters, deboners, rotary washers, refiners, screw presses, block formers, as well as pumps and conveyers for a line to produce 1,000 lbs/hr (from 5,000 lbs of fish) at a cost of over 1/2 million dollars. This does not include a building, cold storage, plate freezers etc. This high investment forces the processor to produce high volumes because surimi may only be worth \$1.50/lb and lower grades may be worth only \$.75/lb" (Clauden 1990).

operating Requirements

The specific operating requirements of a standard surimi line are variable depending on the operation. One could imagine that the energy, water, and labor demands of a surimi line are considerable,.

Equipment Availability

Equipment is available in the Northwest from Clauden, Inc. and in Japan.

Product Suitability for Northern Squawfish

Surimi production requires fish with specific flesh qualities. The appropriateness of northern squawfish is unknown.

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REPORT C

**EVALUATION OF HARVEST TECHNOLOGY
FOR POTENTIAL SQUAWFISH COMMERCIAL FISHERIES
IN COLUMBIA RIVER RESERVOIRS**

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ABSTRACT

A subsidized commercial fishery for northern squawfish (*Ptychocheilus oregonensis*) was conducted in the John Day Reservoir on the Columbia River during the summer of 1990. Three 19-24' Tribal **gillnet** fishing boats were **outfitted** for **longlining**. Salted salmon smolts were provided by this project for use as bait. The Tribal fishermen operated with ODF&W observers aboard their boats from June 12 through August 9. Significant findings are as follows:

- I. The **longline** system developed for this fishery in 1989 was readily transferrable to small commercial fishing boats presently on the Columbia River;
 - only slight modifications to this years methods and procedures need to be made for a future fishery,
 - per boat costs for outfitteding were approximately **\$2,500.00**,
 - two-man crews can easily fish up to 500 hooks per day,
 - structural modifications for installation of our **longline** gear system onto boats are minimal.
- II. Small boat longlining by Tribal fishermen is a viable partial alternative to northern squawfish control on the Columbia River;
 - there is significant Tribal interest in bounty fishing (16 applicants for three test fishing positions),
 - the best times to fish for northern squawfish (April-August) would be at slack times of the year for salmon fishermen,

- Tribal fishermen learned the techniques quickly and **equalled** or exceeded UW 1990 ~~test~~ fishing catch rates,
- conflicts with sport fishermen and river boat traffic were minimal.
- incidental catch mortality is a minor problem; there was no observed mortality during holding experiments **in 1990** and channel catfish (*Ictalurus punctatus*) and white sturgeon (*Acipenser transmontanus*), the only non-squawfish species taken in significant numbers, composed approximately 24.3% of the total **longline** catch.

III. **Longline** catch rates per unit effort on northern squawfish were sharply lower in 1990 than in 1989; either the population had declined or environmental differences between the two years affected **longline** catchability.

IV. The 1990 catch rates by Tribal fishermen may have been impeded (and could be higher in the future) due to several circumstances:

1. structural failure within the **longline** spools prevented optimum fishing effort for a large portion of the season,
2. the bait was less than optimal,
3. the fishing season started late,
4. water flows ~~may~~ have been abnormally high and temperatures too cold for much of the early season,
5. operational flexibility was impeded by the requirements of on-board observers and a rigid fishing schedule,
6. the fishermen were initially inexperienced in squawfish capture,

7. the fishermen may have had inadequate financial resources early in the season.

We also conducted further test fishing with purse seines: a 350' x 30' drum seine from a 22' Boston Whaler outboard boat and a 600' x 60' block seine from a chartered 36' herring seiner. Tests from Bonneville **tailrace** to **McNary forebay** in August and September did not yield encouraging catches of northern squawfish. Purse seining at this time of the year does not appear to be an efficient method for squawfish control in the Columbia River. Possibly earlier in the year when squawfish tend to be in denser schools, purse seining may be effective.

Our methods for handling bait for the three Tribal fishermen and the 22 dam anglers is also provided. Salted frozen salmon smolts were the most reasonable bait to supply to these fisheries, and the amount of effort involved in gathering, storing, and processing the bait is detailed along with approximate costs.

INTRODUCTION

During 1989, we tested several different techniques of commercial fishing for capturing northern **squawfish** (*Ptychocheilus oregonensis*) in Columbia River reservoirs (Mathews et al. 1991). Our main conclusion was that longlining had the best potential for adaptation to small boats of the type commonly deployed in Columbia River commercial fisheries. The prototype hand-operated gear that we developed following 1989 test fishing would be inexpensive to install and operate, would capture northern squawfish at **sufficient** rates to attract **fishermen** if a reasonable per-fish subsidy was provided, and would cause relatively little incidental capture mortality on desirable species.

We also concluded that purse seining should be tested beyond our 1989 efforts because this offered the potential opportunity of capturing large numbers of **squawfish** at certain times and places, and purse seining had in past studies yielded occasionally high catch rates.

Accordingly, **ODF&W** and BPA decided to proceed with a test, small-boat, **longline** fishery in 1990, utilizing three commercial fishermen selected according to a set of objective criteria from a list of those fishermen that might apply. Since Indian fishermen from the four upper Columbia River tribes with U.S. court determined fishing rights have certain exclusive rights above **Bonneville** Dam, it was decided to select the three test fishermen from interested members of these four tribes. Each selected fisherman would provide his or her own boat and crew, but **longline** equipment and terminal gear would be furnished to these fishermen by the UW. Each would enter into a contract with **ODF&W** and be paid a base fee per month of fishing time and an additional subsidy of \$4 per northern squawfish. An **ODF&W** observer would be aboard each boat during all on-water fishing activities.

The **UW recommended** which fishermen should participate in the fishery, according to criteria agreed upon with **ODF&W**. We provided all **longline** equipment and gear to the three fishermen, installed the equipment in each of the three boats, and conducted dry-land and on-water instruction on use of such gear. We also maintained close **communication** with the fishermen during the season for exchange or repair of lost, broken, or inoperable gear, and for flow of information among the group. During the fishery, we periodically sampled each fisherman's catch to obtain incidentally captured white sturgeon (*Acipenser transmontanus*) and channel catfish (*Ictalurus punctatus*). These were live-transported to holding pens for assessment of hooking and handling mortality.

Following the fishing season, we conducted exit interviews with each of the three fishermen to help us evaluate the fishery and make recommendations for future **longline** fisheries.

The UW operated a fourth **longline** boat for test purposes. Primarily, we wished to compare catch rates of the Indian boats with those of our own boat to determine whether or not the technology developed during 1989 had been effectively transferred to the subsidized fleet, or improved upon by the Indian fishermen. We fished this boat in similar areas at similar times as the Indian boats. Additionally, we used this vessel to test several factors related to improving **longline** efficiency that had been **insufficiently** investigated during 1989: (1) alternative baits, (2) time of day for greatest catch rates, and (3) hook spacing.

Our 1989 test purse seining was not very productive. Of several test areas in the John Day and McNary reservoirs, only the spill basin at **McNary** Dam yielded northern squawfish in any numbers, but the catch rate was only about five squawfish per set. A review of past research purse seining revealed that occasionally catches in excess of 100 squawfish per set

have been made in Columbia River reservoirs (Mathews et al. 1991). Furthermore, recent purse seining for squawfish in **Cultus Lake**, B.C., was quite **successful** (**Robert Levey**, Canadian Department of Fish and Oceans, personal communication).

Thus, several questions about purse seining remained. Perhaps our test seine was too small (350' long x 30' deep). Perhaps we could effectively seine near observed areas of high concentrations of squawfish such as the **McNary** powerhouse **tailrace** if the hydro flows were altered or reduced. Perhaps an experienced **commercial** seiner is needed. Perhaps submerged flood lights would concentrate squawfish at night and improve seine efficiency.

Our 1990 purse seine efforts addressed these questions. We fished at night with and without lights; we chartered a commercial herring seiner with a net larger than ours (600' long x 60' deep) and an experienced skipper and crew, and we attempted to coordinate seining activity with reduced power generation at **McNary Dam**. These activities are **described** below.

Another task of our 1990 contract was to provide bait suitably preserved for the **longline** fishery as well as the ODF&W-operated dam angling tests. We contacted private and public hatcheries to obtain **salmonid** fingerlings, the preferred bait according to 1989 tests. We found that there was a substantial availability of culls (fish too small for targeted use) or fingerlings with no available market from private firms discontinuing operation at a particular site. Consequently, we were able to secure large quantities of such bait at relatively low direct **cost**. However, there were various indirect costs, problems, and manpower requirements associated with the procuring, processing, and delivering of bait. Since bait is so important to the **success** of longlining and dam angling, we discuss our experiences on behalf of this particular task in some detail.

SUBSIDIZED LONGLINE FISHERY

Selection of Fishermen

ODF&W mailed an announcement of the project and application forms (Appendix C-1) to the Yakima, Nez Perce, Warm Springs, and **Umatilla** tribes. The returned applications were transferred to the UW for evaluation on 10 May 1990. We received 11 applications from **Yakima** fishermen, 3 from Warm Springs, and 2 **from** Nez Perce fishermen. We also had one fisherman from the Warm Springs tribe contact us through a third party, but when we tried to contact him he failed to return our call. After a substantial effort to contact him, he was dropped from the list of potential fishermen.

The 16 **remaining** applications were scored according to a technical evaluation of each application (1-5 points) and the results of a reference questionnaire (1-15 points, Appendix C-2). Those fishermen with the top six combined scores were notified on 15-16 May 1990, and personal interviews were scheduled for 18 May 1990. The interviews consisted not only of questions about fishing experience, but also inspection of each boat to assess seaworthiness and adaptability to longlining, and an on-water check of the boat handling **ability** of the prospective fishermen (Appendix C-2). The six applicants' interviews were scored (12-36 possible points). By summing **all** possible points **from** each of these steps, the three people with the highest scores were chosen as well as two alternates. We were unable to contact one of these five fishermen after repeated efforts. Our final recommendations were then sent to **ODF&W** for approval (Appendix C-3).

Gear Installation and Description

During the week of June 5-8, we outfitted the three selected fishermen's boats at our **Umatilla field** station, with the help of the fishermen themselves. All three boats were outfitted, tested, and ready to start fishing on June 12. The major pieces of equipment we installed included the hand-operated reel, a suitable **fairlead** for guiding the ground line during setting and retrieval, and a stand for holding the boards containing the hooks and gangions. Each boat was unique in its final design for deploying the **longline** and therefore certain pieces had to be manufactured individually for each boat. All other gear was distributed to the fishermen at this time including hooks, snaps, buoys, hook boards, etc. **Appendix C-4** includes a detailed list of gear provided to each fisherman as well as the approximate cost of the gear. It cost approximately \$2500.00 to outfit each fisherman

The **longline** reels were purchased from a vendor in Florida and designed for use in marine **longlining** off the **Florida** coast. They are equipped with a drag system and removable spools. We found the spools to hold four longlines that were approximately **330-feet** long each and therefore initially provided four spools to each **fishermen**. This allowed them to fish 16 **330-foot** lines, and at 50 hooks per line, we felt this would be an adequate supply of spools and line with which to start the season. The number of lines fished increased beyond this amount as the fishermen became more proficient at setting the gear. We used 300 lb. test mainline (diameter = 1.8 mm) with brass stops every two feet. A one-piece, molded plastic, **gangion** snap was used with 30 lb. test leader and **3/0** Kahle horizontal hooks (English bait hooks) (see Mathews et. al. 1991). Saturn yellow Polyform A-O buoys (**10"** dia) were used for marking squawfish longlines, and pieces of scrap iron from 5-15 pounds were used

as anchors. The fishermen were provided with all necessary gear to fish 16 longlines in any method they chose, as well as all necessary hardware, such as hook removers, that would be needed for all phases of commercial longlining for squawfish.

Schedules and Procedures of Fishery

Table C-1 shows the schedule for the fishermen by designated fishing areas. Because it was known that catch rates would be variable by location, we decided to rotate fishermen throughout the reservoir in order to allow each of them a chance at the more lucrative areas. Also, it allowed us to compare catch rates among fishermen. By providing each fishermen with his own area each week, conflicts with sport fishermen and other commercial users of the river were reduced due to fewer lines set per area. Also to avoid sport fishing conflicts fishing occurred Monday through Thursday from 4 **a.m.** to 2 pm. The sport fishery seemed to be most active in the late afternoon and evening, through dusk.

The Umatilla area was the smallest of the three areas. It was bounded to the east by the **McNary Dam tailrace** boat restricted zone (**BRZ**) and to the west by an imaginary line across the main stem of the Columbia river at the confluence of the Umatilla river (approximately river mile 289). Catches were predicted to be highest in this area and most of the fishing occurred above the Umatilla bridge near the BRZ. The fishermen were required to meet the observer at the Umatilla marina boat ramp at the start of each day.

The Irrigon area was bounded by the Umatilla area on the east and by another imaginary line across the main stem Columbia river at the **Boardman** marina boat ramp (approximately

river mile 269). The fishermen were required to meet the observer at the **Irrigon** marina boat ramp at the start of each fishing day when they were assigned to this area. The catch rates were expected to be good in this area according to 1989 catch rates.

The Arlington area was bounded by the Irrigon area on the east and the John Day Dam forebay **BRZ** on the west. Fishermen were required to use the Arlington boat ramp for meeting with the observer at the start of each fishing day. Catch rates were expected to be the lowest in this area.

The fishermen were responsible for arriving at the assigned boat ramp of their particular area by 4 am, Monday through Thursday of each week. They would either have all their hooks pre-baited with bait received from the **ODF&W** observer the night before or they would collect their bait that morning, proceed to bait **all** the hooks they felt they would set for that day, then go out and set their gear. One fishermen would often use the same baits for several days at a time. It took approximately two hours to set all the lines they were going to fish for the day. They set an average of 320 hooks per day with a range from 80 to 535 hooks per day. They were allowed to fish only single lengths of **longline** in order to avoid conflict with sport fishermen and other boat traffic. As the season got under way this restriction was relaxed as we determined that more than one **longline** per set did not significantly increase the chance of conflicts. They would then wait until around noon and begin to retrieve **all** of their lines. This took approximately two hours. The fishermen were required to have **all** of the **longlines** out of the water by 1:45 p.m.

When all of the lines were retrieved, the fishermen would return to the marina. The squawfish were counted by the observer and a receipt was filled out for the subsidy at \$4.00 per squawfish. Then the fishermen spent from 1 to 8 hours preparing their gear for the next

day's fishing. The large range in off-water effort resulted **from** how the fishermen managed their gangions. Two of the fishermen spent more time pulling the longlines and placing the **gangions** back on the hookboards in a orderly fashion. This resulted in spending roughly 1 to 2 hours examining, organizing, and sharpening hooks. One fisherman placed **all** of the **gangions** that were removed from the **longline** on the deck of his boat or in a steel tub which resulted in roughly 4 to 6 hours of untangling **gangions** and an **additional** 1 to 2 hours of examining, organizing, and sharpening hooks. Oddly enough, the fisherman that was the most inefficient at handling the **gangions** caught the most squawfish. Undoubtedly, gear handling efficiency and catch rates are not entirely related.

Results of Indian Fishery

The catch rates for the **longline** fishermen were lower than predicted. We had anticipated catch rates of better than one squawfish in 12 hooks set, which was our catch rate in 1989 test fishing, however the average catch for the subsidized **fishery** was one fish in 22.5 hooks as seen in Table C-2. There was a significant difference in catch rates between Fisherman B and Fisherman C in this table indicating that catch rates are dependent on the fishermen's skill level and, probably more important, amount of effort. It was our conclusion that a fisherman's chance of catching **squawfish** was directly related to the amount of gear set by that fisherman. The squawfish seemed to be in small moving congregations and when one squawfish was caught, generally one to four more squawfish were caught on nearby hooks on the same longline. Finding these small congregations of fish was difficult since a fisherman could fish the same location two or three days in a row and only have a high catch on one of those days. Therefore, if a fisherman distributed his sets over a wide area, his catches tended to be better than if he were to lump the same number of sets together in a smaller area.

In 1989 we caught squawfish throughout the water column and therefore suggested **to** the Tribal fishermen that they fish their longlines from the surface to the bottom of the river, making baits available at all depths of water. The **fishermen** found that they were only catching **squawfish** near their anchors, however, and switched to fishing most of their longlines strictly near bottom for the majority of the summer. This increased their incidental catch of sturgeon **and** channel catfish to a small degree.

The 1990 catch rates by location (Table C-3) show that fishing in the Irrigon area was **almost** as successful as fishing in the Umatilla area according to hooks set per squawfish caught. In **1989** our catch rates were three times higher (fish per hook set) in the Umatilla area than in the Irrigon area. This suggests that the squawfish may have been more widely distributed throughout the reservoir and not in the densely packed schools in the Umatilla area that we had observed in 1989.

Results of UW Test Fishing

Due to unforeseeable problems within the Tribal commercial fishery, we were unable to commit as much time as we had planned to the further testing of the **longline catching** efficiency. Our test boat was essentially out of service while we were solving the **longline** spool breakage problem. We donated all of our spools to the commercial fishermen. Also, much more time was spent observing and interacting with the fishermen than we had anticipated; we generally spoke with each fishermen one to two times per week for various reasons. We did do some test fishing once the commercial season was over, however.

Bait Comparisons. Table C-4 shows the results of numerous tests that were performed. Lines were generally set with alternating bait types on each separate hook, half of the baits being large salted smolts. Lamprey ammocoetes worked exceptionally **well**; however, use of these as a primary bait source is highly questionable. Sand shrimp and shad work **well**, but they require special handling to maintain their integrity. Adult lamprey pieces as bait could use further investigation since only one **squawfish** was caught on the day this bait was tested.

Time of Day Comparisons. **These** tests were restricted severely due to factors out of our control. However, three days of fishing 24 consecutive hours did occur in August, and some general trends were discovered. The squawfish catch rates were relatively consistent throughout the day and night except for a noticeable decrease in catch in the afternoon (around 1 p.m. to 5 p.m.) and a slightly smaller decrease in catch just after sunrise (around 6 a.m. to 9 **a.m.**). The best times to catch squawfish are in the evening and just before sunrise.

Hook Spacing Comparisons. We also compared catch rates when hooks were spaced 6 feet apart (50 hooks per **line**) and 12 feet apart (25 hooks per line). We found that in any particular area, catch rates (number of hooks set per squawfish caught) were almost always the same. Therefore, setting more hooks per line **can** be more productive in many areas. However, we also discovered that our catches of squawfish were clustered. Because of this, we still feel that setting more lines with fewer hooks per line can be more effective, since the chances of catching squawfish increases with the amount of area being fished.

Incidental Catch Rates

Incidental catch rates were about the same as we observed in 1989 (Table C-5). Overall, incidental species composed 25.8% of the **longline catch** in 1990. White sturgeon composed a higher percentage of the catch this year (14.9%) than last year (11.2%) while a lower percentage of channel **catfish** were captured (9.4%) as compared with last year (11.4%). One Walleye was captured in the Umatilla area and one Small Mouth Bass was captured in the Irrigon area.

Hooking mortality studies were continued in 1990. **Fifty-eight** white sturgeon and 21 channel catfish were held for observation with no observed mortality (Table C-6). However, three of these channel catfish were missing from the holding **pen after** one or two days. One sturgeon was captured with a **longline gangion, from** a previous encounter with this gear, hanging out of its mouth (the hook was well into its stomach). The fish was held for 2 days and appeared healthy, so we cut the **gangion** and released the fish with the hook still in its stomach.

Technological Problems

Many gear problems developed over the course of this project. The biggest problem was the weakness of our **longline** spools. The spools would "**explode**" if **any** amount of pressure was on the monofilament line as it was being retrieved. One fisherman discovered this after breaking two spools in one week. He started pulling lines off the spools after the lines had been retrieved and rewinding them much looser on the spool. Another fisherman was not quite as aware and destroyed all four of his spools before mentioning the problem to us. We

were able to **supply** this fishermen with our test boat spools and began working on some form of support mechanism for the remaining spools as well as ordering additional, stronger spools. The manufacturer was very cooperative in replacing **all** the broken spools, and he also redesigned the spool and sent us a more durable version. We were able to work with a local machine shop to design metal support tabs that could be attached to the spools to strengthen them until the newly designed spools arrived. However, this whole process required several weeks out of an already short season; it took two weeks to get additional spools and one week to attach the metal supports to these new spools and distribute them to the fishermen. It was six weeks later that the redesigned stronger spools made of a different material arrived. Therefore, for three weeks two of the three fishermen were restricted to **fishing** a limited amount of longlines because they could only use the spools which hadn't broken past the point of being usable. The third fisherman was probably not affected in efficiency by the weak spool problem because at no time, even later in the season, did he set more than 10 lines (enough to fill 2% spools). This fisherman also broke only one of the original four spools when no replacements were available.

The second most significant gear problem was with the fish hooks. They seemed to lose their point relatively quickly. Once they had been sharpened the first time by the fishermen, they rusted rather quickly, apparently due to the reaction of the salted bait on the exposed metal of the hooks once the nickel plating had been scratched off. It will probably be difficult to solve this problem without simply replacing the hooks every other week or so. A stainless steel hook with a similar design is available that might work better and resist rust, but stainless hooks would not deteriorate in the mouths of the large sturgeon and other desirable incidental species that might break off the longlines.

One fisherman had problems with losing anchors. One method shown for tying the anchors to **gangion** snaps used monofilament line and line sleeves that are crimped tight. If these are crimped too tight the monofilament will be cut and break easily. We think this is what happened with this fisherman's anchors. The other fishermen did lose a few anchors but reinforced their setups with metal wire after losing only a few.

Other problems resulted such as over inflation and explosion of buoys, lost tools and materials, and excess **salt from** the bait dumped in the parking lots of some of the marinas. These problems were addressed on an individual basis, however, similar problems could be encountered in future **fisheries**.

Other problems were related to adherence to our established rules and regulations. These may have been unclear at the outset and some of the regulations did prove to be too stringent. One such regulation was fishing only one line per set. This issue was addressed as the season progressed and the regulation was changed to **allow** setting any number of **330-foot** lines in a single set. There was also some confusion as to who (UW or the fisherman) was responsible for gear lost and broken during the fishing season.

Water Resource Conflicts

Water resource conflicts were minimal. The fishery avoided high use times for recreational fishermen (evenings and weekends); however, there were two isolated instances where sport fishermen were seen pulling their boat along a **longline**, presumably checking for fish. The fishermen left the gear as soon as the Tribal fisherman approached. Boat

identification numbers on the sport fisherman's boat were written down on the observer's data sheet on one occasion, but no follow up action was taken. We do not know if the boaters were looking for squawfish for the sport bounty or other desirable species.

There appeared to be a general resentment of the commercial **fishery** by the sport fishermen at the beginning of the summer. The ODF&W sport bounty creel clerk at the **Umatilla** boat ramp had several sport fishermen express concern about the **longline** fishermen. This seemed to relax quite a bit once more information was released stating that there was an observer aboard each vessel and that no walleye were being caught on the longlines.

A final water use conflict involved Tribal **fishermen** setting lines within the **McNary tailrace** boat restricted zone. Even after repeated reprimands for fishing inside the restricted area, the fishermen continued to set **lines** over the boundary. The fishermen's reasoning for this was that fishing was not very successful outside the **BRZ** and they had heard how successful the sport bounty shore fishermen were doing inside the **BRZ**. The fishermen felt that the commercial fishery was being discriminated against by not being allowed to fish where the squawfish were obviously most dense.

Exit Interviews

Interviews were held with each fisherman after the season. These were structured **to the** degree that common questions were asked of each (Appendix C-5); however, we attempted to keep these as informal as possible to elicit frank responses and helpful suggestions from the fishermen. We spent one to two hours with **each** fisherman.

Several, questions related to the previous experience of the fishermen. From these, we determined that the average length of previous commercial fishing experience was 13 years. Two of the three individuals had previously longlined for sturgeon, and all had gillnetted **salmon** and steelhead. Two of the three had commercial fishing experience outside of the Columbia River. Other questions related to potential uses of **squawfish**. In general, the fisherman could think of no particular use for **squawfish** and did not think that a non-subsidized squawfish fishery would be viable.

We asked the fishermen to rate the various items of gear and equipment according to poor, okay, or good. Assigning numbers 1-3 to these three responses, respectively, and averaging the scores, we see that the hooks and spools were the major items of concern (Table C-6). Comments revealed that the hooks were difficult to keep sharp. At **first** sharpening, the noncorrosive plating material is removed, and the point then becomes prone to rust. The line spools caused considerable problems as we mentioned before because they were plastic and tended to 'blow apart' when subject to the pressure of the nylon ground line if wound too tight.

Various suggestions were made for improving the gear, including: making a line snap with a wider gap for inserting on the ground line; using a motor-driven ground **line** drum, using a wider line spool which could hold more ground line; having fairleads on both sides of a boat; and using stainless **steel** hooks.

Regarding the bait, which was salted and. frozen whole **salmonid** smolts, two fishermen gave it an "okay" rating and one said it was "good." **Problems** were that it was too variable in size; if too small, it tended to be too soft, and if **too** large,-it needed to be cut in chunks, which were reported to be less effective than whole bait. All fishermen felt that the ideal bait should

be about 3" long. In general, the bait supplied tended to be **larger** than this; much of it was **4"** or larger. One fisherman suggested the use of marine sand shrimp and another mentioned that he had been contacted by a **commercial** bait harvester from the coast about supplying **him shrimp** for bait.

Two of the three regarded the quality of advice, service, and support on fishing techniques by UW as "okay" and the third responded "good." The main problems were apparently a less than adequate supply of anchors and the time spent in resolving the structural weaknesses of the spools.

Regarding administrative support, all three responded "poor." Several problems surfaced about financial and contractual matters. The fishermen stated that their monthly payment in the contract was less than the amount initially stated in the advertisement to apply. The liability insurance was also an issue; it was not known if all fishermen actually obtained this, but the lack of clarity on this issue caused some unease. They were also displeased by what they felt were late payments for their efforts, stating that this caused them to be unable to pay their crews on time and to buy sufficient gas and other operating supplies particularly **early in the season. One fisherman suggested that the per-fish subsidy be paid on delivery of the fish, as is customary and expected with regular commercial fishery operations.**

There were two questions relating to restrictions placed upon the fishing activities which may have limited effectiveness. Several concerns were stated. First, the requirement of fishing on a ten-hour schedule created inefficiency; they felt that when fish were available, it would have been advantageous to fish longer days or perhaps **all** night. Also, the initial limitation

on setting only single 330 foot lines seemed unnecessary. **The** fishermen felt that they could have easily fished twice as many hooks per day as they were allowed, if this restriction was removed and more spools had been provided.

The presence of an observer was also felt to have negatively affected the catch rate. It was not that the observers got in the way or slowed the operation down by their data collection activity, but that the need to coordinate times and places at which to meet them caused inflexibility in fishing schedules. Without having to meet an observer's schedule, a fisherman would be freer to fish when and where he wished.

All three fishermen said 'yes,' when asked if they would fish for squawfish in the future for simply the \$4 bounty. There were some conditions, however, including a longer season (April 15 - August **12**), need for immediate payoff, and more flexible restrictions as discussed above.

PURSE SEINE TESTING

UW 22' Boston Whaler

We conducted a series of purse seine tests in the McNary Dam **tailrace** and **forebay**, using our 300' x 30' purse seine. Due to the high number of hang-ups in the McNary **tailrace** BRZ last year, we made slight changes in the purse seine for this years sampling. The steel purse rings were replaced with neutrally buoyant rings and a floating purse line was installed to keep from snagging large rocks and unseen structures in the shallower areas. We didn't feel that this would change the effectiveness of the seine.

During the period August 7-17, we made a total of 29 sets in various areas and caught only one squawfish for the entire effort; we caught very few of any other fish (Table C-7). The areas seined included both Washington and Oregon shores of the **forebay**, up to about two miles east of the dam; the McNary spill basin; the entrance to the navigation locks; the area immediately outside and below the entrance to the locks; and the Washington shore between the lock entrance and the bridge.

We made four nighttime sets (10 p.m. - 1 a.m.) in the spill basin near the fish **collection** and barging **facilities** with the hope that the floodlights there might attract squawfish. We caught no fish in these sets.

During the period of these seine tests, the Corps of Engineers had power generation units 1-4 shut down. We anticipated that such a shutdown would allow us to test seine **along**

the powerhouse near these units. Several circumstances prevented our fishing there, however. The Corps was reluctant to allow us to fish immediately below the powerhouse because of the bird deflection wires; these hang low enough in the center of the span that the mast of our boat might have reached them. The current tends to circulate northward along the powerhouse and if we had set off units 1-4, we could have been drawn into the center of the powerhouse. Outside of the bird wire area, we measured depths in many places that were less than the depth of our seine (< 25') and the bottom appeared very irregular. Finally, even with power generation shutdown at units 1-4, there was still substantial current in that area.

We did attempt to fish in the main current below the power house (estimated speed of 3 mph). We made three attempted sets about 1/4 - 1/3 mile below. Each set aborted. The net would either sink in the turbulence, or on the one occasion where the current was smooth, we did not have sufficient power to close it up.

We are uncertain why seining was not effective in our 1990 tests. During 1989 in the spill basin, we averaged five squawfish per set and usually caught several fish of other species as well. In most of our seine sets in 1990, we attempted to fish areas of about 30' deep (the depth of the seine) to hopefully minimize the escape of fish under the net. On two occasions, we brought up rocks in the seine but caught no fish. Although we did make slight modifications to the gear by installing a floating purse line, the net "appeared" to be fishing as well as it had last year.

Chartered Herring Seiner

From September 10-19, we did purse seine test fishing with the 36' boat Bay Harvest, chartered through Duane Edwards of Newport, Oregon. The purpose of the charter was two-fold: to determine if **squawfish** could be successfully harvested in a large (600' x 60') purse seine and to determine if shad fry could be caught this way for use as **longline bait**. We fished a number of areas near the four projects from **McNary forebay** to Bonneville **tailrace**. We made a total of 45 sets, some of which were with the smaller (350' x 30') UW seine. The results of each set are summarized in Table C-9. The catch totals are given in Table C-10. We caught a total of 26 northern squawfish which ranged from 200-400 mm forklength and averaged 348 mm. At an average of less than one squawfish per set, this is clearly an insufficient method, at least for the time of year tested. Shad fry were very numerous, but too **small** for capture in the 1% stretched mesh net. Commonly, hundreds or perhaps thousands were seen in the seine, but most escaped **through** the mesh. Few problems were encountered **with** incidental species. With the exception of one dead adult Chinook, salmon and steelhead appeared viable at release. Several Chinook **smolts were** gilled in the mesh and thus killed, but the abundance of smolts in the net was low. Many of **our** sets **were** made with the lead-line entirely on the bottom. Occasionally, this caused lead-line roll-ups or produced snags, but generally problems of this kind were not serious.

We also tried submersible lights in order to determine if northern squawfish could be attracted to an area and then seined. To do this we placed a **small** generator in our 17' Boston Whaler and hung swimming pool lights over the side of the boat. After letting the lights sit for 1-2 hours, we would return and make a set around the boat. Only a few of these sets were attempted and success was low. We felt that our method for lighting was probably the cause of our low success. There tended to be a lot of movement in the boat with boarding, pulling

up the anchor, and maneuvering the boat within the seine while the set was taking place. This should be tried again with some sort of remote lighting apparatus that could remain undisturbed until the seine haul was complete.

The general feeling among everyone involved in the seining, including the crew of the Bay Harvest, was that we just plain didn't have the right gear for the right job. It is likely that a net should be built specifically for each tailrace and forebay to be seined because there is such a large degree of variation in depth between the different projects. There is also large differences in depth within particular forebays. Thus, specialized seines or tow nets could probably be very efficient during the seasonal peak of squawfish abundance.

BAIT PROCUREMENT AND PROCESSING

In 1989 we determined that salmon **smolts** were the best bait to use during summer fishing for northern squaw-fish. Due to our need for several thousand pounds of bait for our 1990 fishing effort, we decided to use salted and frozen salmon smolts for bait. The reasoning for this was that since we had to stock pile bait for 3 **longline** fishermen, 22 dam **anglers**, and ourselves, the smolts would have to be frozen for storage. Salting is definitely required before freezing to produce a firm bait that will stay on the hook once it is thawed. A smolt simply frozen without salting is too soft when thawed. **Also**, salted and frozen smolts caught **squawfish** nearly as well as fresh smolts in 1989.

We experimented with the salting and freezing process and determined that the following procedure is optimal:

Smolts are placed live into a suitable, drainable container in small lots (**15-20** pounds). Then an equal weight **lot** of rock salt is added and the batch is mixed thoroughly. This process is **continued--small** lots of smolts with equal lots of salt-until the **container** is full. Then, the mixture should be stored in a cool environment (**<50** degrees F is best) and given at least two days to drain. It may be desirable to place pressure on the mix by placing boards and weights on top of the open container, although we did not always do this. After most of the moisture **has** drained, the bait can be split into reasonably sized lots using plastic bags. We found 4 gallon bags the best size for handling (5-10 Ibs per bag). The bags of bait should then be frozen and held preferably at less than 10 degrees F. Once the bait is removed from the freezer it will last for up to a week on ice in a cooler or in a refrigerator.

Our 1990 contract specified that we **furnish** bait for the darn anglers as well as the 3 commercial **longline** fishermen. Pre-season estimates were that these two programs might require about 300,000 baits. The actual needs were quite a bit less than this because the **longline** season was shortened, and the darn anglers ascertained during the season that salted frozen baits were not optimal. The latter program tended to use fresh **smolts** as available from smolt collection facility mortalities over the course of the summer.

Nonetheless our preseason plan required us to process 300,000 smolts at an average size of about 6 grams (75 fish per pound), or 4,000 lbs of salted-frozen baits. We contacted private and public hatcheries to obtain mortalities, culls, or if necessary first quality smolts. As it developed, two private fish growers donated most of the smolts we needed. One was a grower in Oregon who was going out of business, and the other a grower in Washington who donated culls in return for a written statement of such a gift. We obtained about 3,000 pounds of smolts from these two sources during the winter and spring of 1990. The additional 1000 lbs (about 100,000 smolts) was obtained from a **private grower in Oregon** on a low-bid basis of \$0.05 per smolt. We also received minor amounts of culls from public hatcheries. All of our baits were Coho salmon smolts.

Even though most of the bait was donated, there are significant costs associated with the processing, transportation, and storage of this bait. Considerable time is required to properly salt and package the bait. We estimate that to salt and package a standard tote of bait (500 lbs of **smolts** and 500 lbs of salt) requires eight man hours, plus \$30 for food grade rock salt, \$140 for a 1000 lb tote, and \$15 for plastic bags to package the bait. A location must be found where the tote can drain for two days; this is no easy task. Once the bait is packaged, it must be transported to a freezer facility near the fishing location; this requires additional manpower and mileage costs. Finally, the frozen storage adds to the cost. Our cost for flash

freezing and **cold** storage in a Seattle **facility** and a facility near **Umatilla** averaged \$15 per tote for flash freezing and \$7.25 per tote per month for cold storage. A rough estimate for collecting, processing, and packaging salmon **smolts** for use as bait, not including any direct cost to purchase the bait, is approximately \$0.005 to \$0.02 per bait (depending on distance between hatchery and fishing site and length of time bait is kept in cold storage).

DISCUSSION AND RECOMMENDATIONS

Subsidized commercial longlining in the John Day Reservoir was less effective on northern **squawfish** than we predicted from our 1989 test fishing results. In 1989 we averaged about 1 squawfish for every 12.3 baited hooks set from April-August throughout the reservoir. Catch rates in 1990, including our test catches as well as those of the subsidized fishermen, averaged one squawfish for every 22.5 baited hooks set during the summer months. Either the population in the areas fished declined between the two years or **longline** catchability on squawfish declined for some inexplicable reason. The average efficiency of the three subsidized fishermen was similar to, if not better than, the UW 1990 test fishing results, so the cause was not due to inexperience or ineptitude on the part of the fishermen.

Decline in the population should not be discounted as a **possibility**. The best **squawfish** catches in both years were from the area immediately below **McNary** Dam. Several thousand squawfish have been removed from this region by 1989-90 **longline** efforts, angling **from McNary** Dam, and gillnetting and electroshocking by the population indexing crews.

Another factor possibly contributing to the low 1990 catch rate was water conditions. River run-off was much higher during 1990 than 1989 and spill conditions continued through the first week of July. Higher flows also contributed to lower water temperatures and greater turbidity.

Finally we should mention the bait. Frozen smolts are not totally optimal, although for practical reasons they may be the best compromise among several alternatives in terms of availability and ease of storing and handling. Much of our 1989 fishing was with fresh smolts;

whenever baits have been test-fished side by side both in 1989 and 1990, the fresh **smolts** outfished frozen to some degree. Also, the dam anglers by far preferred the use of fresh bait compared to frozen. We suspect a good source of fresh bait would have improved the 1990 catch rates. If this type of fishery continues in the future, efforts should be made to secure a fresh bait source. Two potential sources that would be somewhat costly include fresh **smolts** and marine sand shrimp. Fresh smolts could be made available on a **daily** basis by an arrangement with a local public or private hatchery to specifically rear **salmonid** fingerlings for use as a daily bait source. Marine sand shrimp are presently available for use in the salmon and steelhead sport fishery. The retail price for recreational fishermen is higher than would be feasible for **longlining** squawfish, but a lower price for volume deliveries to longliners could be possible. We compared sand shrimp to salted smolts in one test, on the suggestion of one of the Tribal fishermen, and found it to be a superior bait in spite of the fact that the shrimp we obtained were soft-shelled from molting. Firm-shelled shrimp would stay on the hook well and might be worth the relatively high price for a subsidized fishermen.

Although squawfish catch rates were disappointingly low in 1990, the **longline** fishery encountered few operational problems. Incidental catch rates on desirable species (white sturgeon, channel catfish, walleye, bass, etc.) were relatively low as in 1989. In fact only one walleye was taken in 1990 (and 1989). Our observations indicated that hooking and handling mortality of incidental species due to capture by the Tribal fishermen was zero (or at most very low). Furthermore, there was little conflict with other water users.

Consequently, subsidized longlining should be considered **aviable**, partial technique for northern squawfish reduction in Columbia River reservoirs. If **longlining** opportunities were made available to more individuals over a wider area, and regulations were relaxed to allow the fishermen more freedom in methods and fishing locations, we feel that catch rates could

improve over our 1990 experience. Squawfish populations are probably higher in the Bonneville and The Dalles Reservoirs than in the John Day Reservoir, according to index sampling in 1990 and relative fish ladder counts at each of the dams. Thus, if the fishery were extended, if better bait sources were tested, and as experience among a fleet of subsidized longliners accumulated, a sufficient catch rate would result so that even at a modest bounty fee fishermen would find sufficient incentive to take substantial numbers of squawfish.

The optimum time to **longline** squawfish is late April through August, a time when Tribal fishermen are not extremely involved with other fisheries. A subsidized squawfish fishery provides them the opportunity to use their boats for alternative income. **Squawfish** removal also has the potential to improve the populations of salmon, which is an additional incentive for them to become involved.

There seems to be little reason not to expand the squawfish **longlining** opportunity to all Tribal fishermen who wish to participate. This is the way to determine the ultimate effectiveness of this method of control. Several precautions should be taken, however.

1. Limitations should be established on lengths of groundline to **minimize** potential interference with anglers, squawfish longliners, and other river traffic.
2. Fishery observers, perhaps on a trial basis, should be utilized as the fishery develops into other areas of the Columbia River to assure that incidental catches of desirable species do not become a problem.
3. **Gangion** breaking strength should be not more than 30 Ibs, so that large sturgeon will not be handled.

4. Gear should be clearly marked on both ends of each **longline** with floats so that all river users can easily identify them.
5. Stainless steel hooks should not be allowed, at least until additional testing may be done, because they would probably tend to remain longer in desirable species than alternative hooks made of more corrosive materials.
6. To encourage fishermen to participate, "start-up" equipment and gear should be provided at no cost. Thus each qualified fisherman might be given a one time package including a hand operated reel and enough spools, mainline; plastic snaps, and hooks to get started in the fishery. Without this provision we believe that the catch rates thus far have not been high enough to encourage many fishermen to make the initial start up investment that would be needed.
7. A manual showing how to outfit a boat for squawfish longlining and operate this particular gear most efficiently should be written and provided to each fisherman. This manual should also provide information on where to purchase additional gear.

Even though our purse seining efforts have not been effective so far, additional test seining should be done, particularly in spring and early summer. This is the time of **squawfish** spawning activity and peak migrational activity as indicated by ladder counts of squawfish. Purse seining on other species is most effective when the fish are either spawning, migrating, or both and therefore we recommend that an experienced commercial purse seiner be utilized at these times for additional tests.

LITERATURE CITED

Mathews, S. B., T. Iverson, R. W. Tyler, and G. Ruggerone. 1991, Evaluation of harvesting technology for potential northern squawfish commercial fisheries in Columbia River reservoirs.. University of Washington. In A. A. Nigro (editor), Final Report for Predator-Prey II Study, BPA Project 82-012.

Table C-1. Subsidized **longline** fishery schedule and area assignments for J. T. Williams, Duane Hoptowit, and Ellen Blevin's crew, 1990.

Date	Designated Fishing Area		
	Umatilla	Irrigon	Arlington
<p>*</p> <p>June 12-15 June 18-21 June 25-28 July 2-5 July 9-12 July 16-19 July 23-26 July 30 - August 2 August 6-9 **</p>	<p>Williams Hoptowit Blevin Williams Hoptowit Blevin Williams Hoptowit Blevin</p>	<p>Blevin Williams Hoptowit Blevin Williams Hoptowit Blevin Williams Hoptowit</p>	<p>Hoptowit Blevin Williams Hoptowit Blevin Williams Hoptowit Blevin Williams</p>

*June 5-8. All fishermen in Umatilla at UW field station for installation of longlining gear.

**August 13-17. Return all fishing gear and arrange exit interviews.

Table C-2. Results of subsidized tribal **longline** fishery by fisherman in the John Day Reservoir from June - August, 1990.

Catch	Fisherman			Total
	A	B	C	
Northern Squawfish	479	675	259	1413
White Sturgeon	94	155	45	294
Channel Catfish	74	63	57	194
Other Species	11	15	6	32
Total Catch	658	908	367	1 9 3 3
NUMBER OF DAYS FISHED	35	34	*31	
NUMBER OF SETS	262	281	171	714
NUMBER OF HOOKS SET	10,735	12,512	8,595	31,842
HOOKS SET PER SQUAWFISH	22.4	18.5	33.2	22.5

* Fisherman C missed the final week of fishing in order to gear up for salmon gillnetting.

Table C-3. Results of subsidized tribal longline fishery by area for June - August, 1990, John Day Reservoir.

Catch	Area			Total
	Umatilla	Irrigon	Arlington	
Northern Squawfish	601	494	318	1,413
White Sturgeon	184	101	9	294
Channel Catfish	48	122	24	194
Other Species	17	7	8	32
Total Catch	850	724	359	1,933
NUMBER OF SETS	267	220	227	714
NUMBER OF HOOKS	12,132	10,826	8,884	31,842
HOOKS SET PER SQUAWFISH	20.2	21.9	27.9	22.5

Table C-4. Bait comparisons with large salted **smolts** as the control. McNary Damtailrace, June-August, 1990.

Bait	Hooks	Squawfish	Hooks/ Squawfish
Large whole salted smolts	240	18	
Lamprey ammocoetes	144	21	13.33
			6.86
Large whole salted smolts	384	11	
Fresh sand shrimp	384	20	34.91
			19.20
			8.00
Large whole salted smolts	384	18	6.00
Fresh whole smolts			
Large whole salted smolts	94	8	11.75
Small yoy shad	95	10	9.50
Large whole salted smolts	288	22	13.09
Small whole salted smolts	240	17	14.12
Large whole salted smolts		69	
Salted smolt pieces	860	46	12.46
	980		21.30
Large whole salted smolts			8.00
Frozen fresh smolts	144	18	24.00
Large whole salted smolts			
Adult lamprey pieces	60	0	N/A
	144	1	144.00

Table C-5. Total catch by species from subsidized tribal **longline** fishery and UW **longline** fishing from June - August, 1990, John Day Reservoir.

	Tribal Fishery		UW Fishing		1990 Total		1989* Total	
	#	%	#	%	#	%	#	%
Northern Squawfish	1,413	73.1	428	78.2	1,841	74.2	525	72.3
White Sturgeon	294	15.2	75	13.7	369		81	11.2
Channel Catfish	194	10.0	40	7.3	234	19.4	83	11.4
Cottids	8	0.4	1	0.2	9	0.4	14	1.9
Yellow Perch	2	0.1	0	0.0	2	0.1	8	1.1
Bullheads	4	0.2	0	0.0	4	0.2	7	1.0
Catostomids	7	0.4	1	0.2		0.3	4	0.6
Carp	2	0.1	1	0.2	4	0.3	2	0.3
American Shad	7	0.4	1	0.2	8	0.0	2	0.3
Walleye	1	0.1	0	0.0	1	0.0		0.0
Small Mouth Bass	1	0.1	0	0.0	1	0.0	8	0.0
Total	1,933		547		2,480		726	

* 1989 UW longline fishing from April - August, 1989, in John Day Reservoir (Mathews et al. 1990).

Table C-6. Length frequency of white sturgeon and channel catfish held for UW hooking mortality study, caught on baited longline and held for >48 hours, Summer 1990.

Fork Length (mm)	White Sturgeon	Channel Catfish
200-249	1	
250-299	0	8
300-349	4	2
350-399	5	2
400-449	6	4
450-499	7	3
500-549	11	7
550-599	9	1
600-649	8	1
650-699	0	0
700-749	4	1
750-799	1	0
800-849	1	0
850-899	0	0
900-949	1	0
Total Fish Held	58	21
Total Mortality	0	0*

* Three channel catfish disappeared from the holding pens.

Table C-7. Scores to questions on adequacy of gear supplied to three tribal **longline** fishermen by the UW, Summer 1990.

1 = poor
2 = okay
3 = good

Item of Gear	Average Score
Reels	2.67
spools	2.00
Fairleads	2.67
Hooks	2.00
Line	3.00
Anchors	2.67
Buoys	3.00

Table C-8.

Results of UW purse seine tests with 350 x 30' seine, August, 1990.

Location	Date	Time	Catch - Comments
McNary spillbasin	August 7	11:00 a.m.	No fish
McNary spillbasin	August 7	1:00 p.m.	No fish
McNary spillbasin	August 7	1:30 p.m.	No fish
McNary spillbasin	August 8	5:00 p.m.	1 adult chinook; 1 adult shad
McNary spillbasin	August 8	10:00 p.m.	No fish
McNary spillbasin	August 8	12:30 p.m.	No fish
Entrance to navigation lock	August 14	11:00 a.m.	No fish
Entrance to navigation lock	August 14	11:30 a.m.	No fish
WA shore 1/4 mi. below navigation lock	August 14	12:00 noon	No fish
McNary spillbasin	August 14	1:00 p.m.	No fish
McNary spillbasin	August 14	1:30 p.m.	1 squawfish
Outside of lower end of navigation lock	August 14	2:00 p.m.	No fish
WA shore 1/2 mi. below navigation lock	August 14	2:30 p.m.	No fish
McNary spillbasin	August 14	9:30 p.m.	No fish
McNary spillbasin	August 14	10:30 p.m.	2 suckers; 1 chislemouth
McNary spillbasin	August 15	10:00 a.m.	No fish
McNary forebay, WA shore	August 15	11:00 a.m.	2 carp
McNary forebay, WA shore	August 15	11:30 a.m.	No fish
McNary forebay, WA shore	August 15	1:30 p.m.	1 adult steelhead
McNary forebay, WA shore	August 15	2:30 p.m.	1 chislemouth; 1 bass
McNary forebay, OR shore	August 15	3:00 p.m.	No fish
McNary forebay, OR shore	August 15	3:30 p.m.	No fish
McNary forebay near navigation lock entrance	August 15	4:00 p.m.	No fish
McNary spillbasin	August 16	9:00 a.m.	1 adult shad
Smolt barging station	August 16	10:00 a.m.	No fish
1/4 mi. below navigation lock powerhouse	August 16	10:30 a.m.	No fish; net sank in current
1/4 mi. below powerhouse	August 16	11:00 a.m.	No fish; could not close net
1/3 mi. below powerhouse	August 16	11:30 a.m.	No fish; net rolled up and sank
1/3 mi. below powerhouse	August 16	1:00 p.m.	

Table C-9.

Summary of test fishing with chartered purse seiner Bay Harvest, 1990.

Date	Time of Day	Depth (ft.)	Seine (ft.)	Lighting	Location	Squawfish	Steelhead Adult	Chinook Adult	Coho Adult	Chinook Smolt	Sucker	Chiselmouth	Carp	Sturgeon	Bass	Sunfish	Steelhead Smolt	Adult Shad	Shad Fry
9/12	10 a.m.	60-90	600x60	No	Middle of McNary reservoir, 1 mi. ea. of dam	0	0	0	0	0	0	0	0	0	0	0	0	0	p
9/12	12 p.m.	20-30	600x60	No	Hat Rock Park, 6 mi. ea. of McNary Dam	0	0	0	0	0	0	2	0	0	0	0	1	0	p
9/12	2 p.m.	30-40	600x60	No	WA shore, 2 mi. ea. of McNary Dam	0	0	0	0	0	2	0	1	0	0	0	0	0	p
9/13	8 a.m.	15-20	600x60	No	OR shore near McNary Dam site boat ramp	0	1	0	0	0	3	2	1	0	0	0	0	0	a
9/13	8:30 a.m.	15-20	600x60	No	OR shore near McNary Dam site boat ramp	0	3	0	0	2	0	2	1	0	0	0	0	0	p
9/13	10 a.m.	15-30	600x60	No	WA shore, 2 mi. ea. of McNary Dam		1	0	0	2	2	0	0	0	0	0	0	0	a
9/13	12 p.m.	30-50	600x60	No	WA shore, 1 mi. ea. of McNary Dam	0	0	3	0	1	10	0	4	0	0	0	0	0	a
9/14	8 a.m.	10-15	600x60	No	Umatilla Yacht Basin	0	0	0	0	0	0	0	2	0	3	0	0	0	a

p (present)
a (absent)

Table C-9. (Continued)

Date	Time of Day	Depth (ft.)	Seine (ft.)	Lighting	Location	Squawfish	Steelhead Adult	Chinook Adult	Joho Adult	Chinook Smolt	Sucker	Chisle-mouth	Carp	Sturgeon	Bass	Sunfish	Steelhead Smolt	Adult Shad	Shad Fry
9/14	9 a.m.	10-15	600x60	No	Umatilla Yacht Basin	0	0	0	0	0	1	0	2	0	0	0	0	0	a
9/14	1 p.m.	30-40	350x30	NO	Below McNary navigation locks	0	0	0	0	0	0	0	0	0	0	0	0	0	p
9/14	1:30 p.m.	30	350x30	No	McNary Spill Basin	0	0	0	0	0	0	0	0	0	0	0	0	0	p
9/14	2 p.m.	30-50	350x30	No	McNary Spill Basin	0	0	0	0	0	0	0	0	0	0	0	0	0	p
9/14	2:30 p.m.	30-50	350x30	NO	McNary Spill Basin	0	0	0	0	0	0	0	0	0	0	0	0	0	p
9/14	3 p.m.	30-50	350x30	No	McNary Spill Basin	0	0	0	0	0	0	0	0	0	0	0	0	0	p
9/14	8:30 p.m.	30-50	350x30	No	McNary Spill Basin	0	0	0	0	0	0	0	0	1	0	0	0	1	p
9/14	9 p.m.	30-50	350x30	NO	McNary Spill Basin	0	0	0	0	0	0	0	0	0	0	0	0	0	p
9/14	9:30 p.m.	10-50	350x30	No	McNary Spill Basin	1	0	0	0	0	0	0	0	0	0	0	0	1	p
9/14	10 p.m.	30-50	350x30	Yes	McNary Spill Basin	1	0	0	0	0	0	0	0	0	0	0	0	0	p
9/16	7:30 p.m.	60-90	600x60	No McNary forebay spillway		1	1	0	0	0	0	0	0	0	0	0	0	0	p

Table C-9. (Continued)

Date	Time of Day	Depth (ft.)	Seine (ft.)	Lighting	Location	Squawfish	Steelhead Adult	Chinook Adult	Coho Adult	Chinook Smolt	Sucker	Chiselmouth	Carp	Sturgeon	Bass	Sunfish	Steelhead Smolt	Adult Shad	Shad Fry
9/16	8 p.m.	60-90	600x60	No	McNary spillway forebay	0	8	0	0	0	0	1	1	0	0	0	0	0	p
9/16	8:30 p.m.	60-90	600x60	No	McNary spillway forebay	2	0	2	0	0	0	6	0	0	0	0	0	0	p
9/16	9:30 p.m.	20-30	600x60	No	OR shore near McNary Dam site boat ramp	1	1	0	0	0	2	0	3	0	0	0	0	0	p
9/16	10:30 p.m.	60-90	600x60	Yes	McNary spillway forebay	2	0	1	0	0	0	6	0	0	0	0	0	1	p
9/16	11 p.m.	60-90	600x60	No	McNary spillway forebay	6	1	0	0	0	0	10	0	0	0	0	0	0	p
9/17	9 a.m.	60-90	600x60	No	McNary spillway forebay	4	4	1	0	0	0	1	2	0	0	0	0	0	p
9/17	10 a.m.	60-90	600x60	No	McNary spillway forebay	2	3	1	0	0	0	2	0	0	0	0	0	0	p
9/17	11 a.m.	15-30	600x60	No	WA shore 1 mi. ea. of McNary Dam	1	0	0	0	0	1	0	0	0	0	0	0	0	p
9/17	5:30 p.m.	15-50	600x60	No	Off Irrigon Marina	0	0	0	0	0	0	0	0	0	0	0	0	0	p
9/17	7 p.m.	13-40	600x60	No	Near Patterson slough	0	0	0	0	0	0	0	0	0	0	0	0	0	p

Table C-9. (Continued)

Date	Time of Day	Depth (ft.)	Seine (ft.)	Lighting	Location	Squawfish	Steelhead Adult	Chinook Adult	Coho Adult	Chinook Smolt	Sucker	Chislic-mouth	Carp	Sturgeon	Bass	Sunfish	Steelhead Smolt	Adult Shad	Fry
9/17	7:30 p.m.	30-40	600x60	No	Near Patterson Slough	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/18	5 p.m.	50-70	600x60	No	John Day forebay	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/18	6 p.m.	50-70	600x60	No	John Day forebay	2	1	0	0	0	0	1	0	0	0	0	0	0	0
9/18	8:30 p.m.	50-70	600x60	No	John Day forebay	1	1	0	0	0	0	1	0	0	0	0	0	0	0
9/18	9 p.m.	50-70	600x60	Yes	John Day forebay	1	0	0	0	0	0	0	0	0	0	0	0	0	0
9/19	6:30 p.m.	25-60	600x60	No	The Dalles forebay	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/19	7 p.m.	25-40	600x60	No	The Dalles forebay	0	0	0	0	1	0	0	0	0	0	0	0	0	0
9/19	8 p.m.	25-60	600x60	No	The Dalles forebay	0	0	1	0	0	0	0	0	0	0	0	0	0	0
9/20	6 p.m.	20-90	600x60	No	Bonneville forebay	1	0	0	0	0	1	0	0	0	0	0	0	1	0
9/20	7 p.m.	20-90	600x60	No	Bonneville forebay	0	0	0	0	1	0	0	0	0	0	0	0	0	0
9/20	7:30 p.m.	20-90	600x60	No	Bonneville forebay	0	0	0	0	1		0	0	0	0	0	0	0	0
9/21	7:30 a.m.	20-90	350x30	No	Bonneville forebay	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table C-9. (Continued)

Date	Time of Day	Depth (ft.)	Seine (ft.)	Lighting	Location	Squawfish	Steelhead Adult	Chinook Adult	Coho Adult	Chinook Smolt	Sucker	Chisle-mouth	Carp	Sturgeon	Bass	Sunfish	Steelhead Smolt	Adult Shad	Shad Fry
9/21	8 a.m.	20-90	350x30	No	Bonneville forday	0	0	0	1	0	0	0	0	0	0	0	0	0	a
9/21	9:30 a.m.	30-45	350x30	No	Bonneville spillway tailrace	0	0	0	0	0	0	0	0	0	0	0	0	0	a
9/21	10 a.m.	30-45	350x30	No	Bonneville tailrace	0	0	0	0	0	0	0	0	0	0	0	0	0	e
9/21	10:30 a.m.	30-45	350x30	No	Bonneville tailrace	0	0	0	0	0	0	0	0	0	0	0	0	0	a

Table C-10. Number of fish taken by the Bay Harvest in 45 purse seine hauls between McNary forebay and Bonneville tailrace, September, 1990.

Species	Number
Squaw-fish	26
Steelhead adult	25
Steelhead smolt	1
Chinook adult	9
Chinook smolt	11
Coho adult	1
Sucker	19
Carp	14
Bass	1
Sunfish	3
Shad fry	*

* very abundant

Appendix C-1.

Letter and questionnaire application sent to participating tribes for subsidized
Tribal longline fishery, 1990.



Department of Fish and Wildlife
RESEARCH AND DEVELOPMENT SECTION

17330 SE EVELYN STREET CLACKAMAS, OR 97015

April 17, 1990

Dear Tribal Fisher:

This letter is to announce a possible opportunity for you to work in an experimental longline fishery for northern squawfish this summer in John Day Reservoir. The fishery is to be conducted by the Oregon Department of Fish and Wildlife (ODFW) in cooperation with the University of Washington (UW). This announcement is not a promise that anyone will be hired. If you are interested in this opportunity, please read the following information carefully.

BACKGROUND

Predation by northern squawfish is a significant cause of mortality to salmon and steelhead smolts in Columbia River reservoirs, and fishery managers are looking for ways to reduce the problem. Researchers from ODFW and UW tested various types of commercial fishing gear in the John Day Reservoir during 1989 and determined that longlines may be effective for capturing northern squawfish. ODFW proposes to continue testing the workability of the gear by hiring three tribal fishers and their boats to longline for northern squawfish during the summer of 1990. Depending on how successful this summer's experimental fishery is, the longline fishery may be expanded in later years to include more reservoirs and more fishers. If unsuccessful, the fishery will not be continued after 1990.

FISHERY DESCRIPTION

Work Agreement

The tribal fishers will be hired, supervised, and paid by ODFW. ODFW will provide research fishing permits, and the fishers will be fishing under the authority of the State of Oregon. Therefore, tribal fishers participating in the experiment fishery must license and operate their boats according to Oregon and federal laws (for example, have required safety equipment aboard). Running lights will probably not be required because night-time operation is not expected.

All fishing activity shall be conducted with an ODFW observer on board the vessel.

Presently, ODFW intends to hire three tribal fishers, each of whom must provide a boat and hire a helper. It will be up to the fishers to decide how much they will pay their helpers. The fishers will work as independent contractors, which means that they will not receive health and medical insurance or any other fringe benefits that salaried or hourly wage employees of the state receive.

Gear

A reel, attached to a davit set into a stanchion, will be installed in each fisher's personal 18-22' boat by UW researchers, probably in late May. This gear is relatively small, lightweight, and easy to remove and install. The lines themselves are 250 lb test monofilament and the gangions (leaders) are 30 lb test to allow larger sturgeon to break free. UW researchers will demonstrate the use of the gear to the tribal fishers before the season and be available for technical assistance during the fishing season. ODFW/UW personnel will provide all longline gear: including hooks, gangion snaps, lines, buoys, anchors, mainline, reel, and other associated hardware. The fishers will be responsible for maintenance of this gear, their boats, motors, trailers, vehicles, and other personal property. Bait will be provided daily by ODFW/UW personnel. All longline gear will be returned to ODFW/UW at the conclusion of the fishing season.

Boat

It is important that the boat be large (at least 18 feet) and seaworthy enough to accommodate three working bodies plus the gear.

Personnel

Two tribal fishers, the fisher hired by ODFW plus his/her helper, are needed to operate each boat. In addition, the ODFW technician will be aboard to sample the catch of target and incidental species and to observe the operation of the gear.

Labor Commitment

Fishing will occur 40 hours per week during daylight hours on 3-4 weekdays per week (approximately 10-12 hours per day) for about 2 months from early June to mid-August, 1990. Specific fishing hours will be worked out with qualifying fishers. Based on past experience, a boat should be able to set and retrieve approximately 10 lines (SO-100 hooks each) per 8 hour day.

Fishing Area

Fishing will occur in areas of the John Day Reservoir outside the John Day and McNary dams boat-restricted areas. Landings may have to occur on only the Oregon shore because of Washington State regulations and logistical considerations. Although fishers may initially be directed to areas where they are likely to be successful, they will later have to decide where to deploy their gear.

Compensation

Fishers will be compensated in two ways: 1) a wage to compensate for foregone employment opportunities, plus 2) a bonus incentive for each northern squawfish longer than 250 mm (10 in) fork length taken from John Day Reservoir in presence of ODFW observer by ODFW approved, longline gear and landed at ODFW designated sites. The wage will be \$2504 per boat per month, and the bonus incentive is expected to be \$4 per northern squawfish. The fisher and his/her helper must decide between themselves how to divide the \$2504 wage and the bounty compensation, as well as how to pay for operating and maintenance expenses, other than for the longlining equipment. Only fish landed in good condition shall be considered for bonus (see Handling of Catch).

Catch rates during preliminary testing during the summer of 1989 were roughly 1 squawfish per 8 hooks set.

Handling of Catch

Northern squawfish will be kept alive on ice (they survive several hours out of water) or in a live-well and delivered to ODFW personnel at the landing site(s). All incidentally-caught species will be sampled by the on-board ODFW/UW technician and released, unharmed if possible. Although ODFW intends to monitor post-catch survival of incidental species, it is unknown at this time what sort of live pens or boxes will be used.

FISHER QUALIFICATIONS

This project requires that the participating fishers have a suitable boat and be willing to hire a helper and commit much time and energy during the summer. Fishers should be flexible as to what days during the week they can work and should discuss with ODFW any exceptions to the work schedules that they may require. Another important qualification for fishers is the willingness to work in close cooperation with researchers and the on-board technicians. A knowledge of John Day Reservoir would also be useful, as would previous longlining experience. Having a summer residence within a reasonable commuting distance of an access site on John Day Reservoir is also important.

Selecting the Fishers

It will be necessary to select three fishers, plus alternates, from the many that are expected to express interest in participating in this study. Completed questionnaires (blank form is enclosed) that are received by the deadline (4 May 1990) will be given a technical screening to determine the fisher's qualifications. References will also be contacted. Criteria for selection will include: 1) suitability of your boat in terms of size, safety, mechanical reliability, and adaptability to ODFW/UW longline gear, 2) length and breadth of your fishing experience focusing mainly on experience in Columbia River fisheries, 3) ease and availability for contact during off fishing hours throughout the fishing season, 4) past record of compliance with state, federal, and tribal regulations. Fishers who qualify will be asked to demonstrate their abilities and the operability of their equipment in Umatilla, Oregon (probably by May 11).

HOW DO YOU EXPRESS YOUR INTEREST IN THIS OPPORTUNITY?

If you wish to be considered for this project, complete and return the enclosed questionnaire to the Oregon Department of Fish and Wildlife, Please call Mr. Ron Boyce at (503) 229-5400, ext. 351 if you have questions. This announcement is not a promise of employment.

QUESTIONNAIRE

If you wish to work for the Oregon Department of Fish and Wildlife (ODFW) in the experimental longline fishery for northern squawfish in John Day Reservoir in 1990, please answer all of these questions as thoroughly as possible. Write clearly and use additional pages if more space is needed. Your completed questionnaire must be received by the close of business on 4 May, 1990. Mail it to:

OREGON DEPARTMENT OF FISH AND WILDLIFE
2501 S.W. First Avenue, P.O. Box 59
Portland, OR 97207
ATTN: Ron Boyce

NAME: _____ PHONE: () _____

MAILING ADDRESS: _____

TRIBE: _____ MEMBERSHIP NUMBER: _____

1. If hired, will you license your boat and comply with all Oregon and federal fishing and boating laws while employed by ODFW on this project?

(circle one): YES NO

2. Are you willing to work under the close supervision of ODFW and University of Washington (UW) personnel and have one of their technicians on board your boat while you fish?

(circle one): YES NO

3. If hired, will you, to the best of your ability, work the hours and days that the ODFW/UW researchers require of you, with the possible exception of commercial salmon season openings?

(circle one): YES NO

4. Are YOU willing to have your boat modified for installation of the fishing gear?

(circle one): YES NO

5. What is the size of your boat? -- Length: __ ___ Width: _____

Can three Persons work comfortably and safely in your boat, even on moderately rough water?

(circle one): YES NO

6. What type of boat motor do you have? Make: _____
Horsepower: _____ Age: _____ Type: (circle one: inboard/outboard,
jet/propellor)

7. Do you have VHF communication equipment aboard your vessel?
(A VHF radio is not required to qualify for this contract.)

(circle one): YES NO

8. In which reservoir(s) do you normally fish? _____

9. If hired, how close would you live during the summer to the
access sites on the Oregon side of John Day Reservoir?

Access site(s)

Miles from summer residence

- a) John Day River- Mouth
- b) Arlington Boat Ramp
- c) Umstilla Boat Ramp

10. On an attached page, briefly describe your experience, if
any, with
1) longlining, 2) experimental fisheries, and 3) working with
non-tribal or tribal biologists.

11. Which tribal Fish and Wildlife Committee members, biologists,
or other persons could be references for you?

a) Name: _____
Phone: () _____
Address: _____

b) Name: _____
Phone: () _____
Address: _____

I hereby attest that this information is true and accurate to the
best of my knowledge and hereby acknowledge that this
announcement and questionnaire do not constitute an Offer or
guarantee of employment by the Oregon Department of Fish and
Wildlife.

x

Signature _____ Date _____

Appendix C-2.

Reference: questionnaire and field evaluation form used for selecting Tribal fishermen for the 1990 subsidized **longline** fishery.

EXPERIMENTAL COMMERCIAL LONGLINE APPLICATION

REFERENCE QUESTIONNAIRE

Fisher : _____ Total _____
 Date : _____
 Reference Name: _____
 Reference Affiliation: _____

- | | | | | |
|----|---|----|---|---|
| 1) | History of involvement with state, federal,
and tribal sampling programs..... | 1 | 2 | 3 |
| 2) | History of compliance and cooperation with
state, federal, and tribal laws and
regulations..... | 12 | | 3 |
| 3) | Would reference hire this candidate to do
similar work..... | 1 | 2 | 3 |
| 4) | Does reference feel this candidate can
operate effectively as part of a team..... | 1 | 2 | 3 |
| 5) | Does reference feel this candidate would
be reliable in following schedules and
procedures..... | 1 | 2 | 3 |
| 61 | What does reference feel are this
candidates abilities regarding boat
operation, catch handling, fishing
expertise, etc..... | 1 | 2 | 3 |

EXPERIMENTAL COMMERCIAL LONGLINE APPLICATION
FIELD EVALUATION

Fisher: _____ TOTAL _____
Date: _____

Boat Evaluation: _____ Total _____
Length..... 1 2 3
Stability..... 1 2 3
Clear deck space..... 1 2 3

Remarks- _____

Engine Condition: _____ Total _____
Age..... 1 2 3
Start ability..... 1 2 3
Performance..... 1 2 3

Remarks- _____

Adaptability of Boat to UW Gear: _____ Total _____
Ease of reel attachment..... 1 2 3
Gear storage space..... 1 2 3
Snags..... 1 2 3

Remarks- _____

Fisher Boat-handling Proficiency: _____ Total _____
Launch/load proficiency..... 1 2 3
General boating skills..... 1 2 3
BUOY test (hold position
alongside navigational buoy
for 30 seconds)..... 1 2 3

Remarks- _____

Appendix C-3.

UW recommendations for participants in the 1990 Tribal longline fishery.

Date: 21 May 1990

To: Tony Nigro

From: Steve Mathews, Richard Tyler, and Tom Iverson

Subj: Recommendations for Experimental Commercial Longline
Fishery

We have reviewed 16 applications for the experimental commercial longline fishery and have chosen four outstanding candidates whom include:

- 1) Ellen Blevin
(crew: Ted Hoptowit and Joseph James)
- 2) J.T. Williams
- 3) Duane Hoptowit

and

- 4) Randy Settler.

Our number 4 choice was so strong that we would encourage contacting him as an alternate in case any one of the top three not work out.

Although you are familiar with our selection process we should include a general summation for the record.

10 May 1990- We received 13 applications and sat down with you and developed an acceptable questionnaire for use in contacting the applicants references.

11-15 May 1990- References were contacted for each applicant and fisher's questionnaires were evaluated.

15 May 1990- Due the short amount of time the first cut decided strictly on a technical evaluation of the applicant questionnaire (1-5 points possible) and the results of a referee questionnaire (1-15 points possible). The technical evaluation was done by Dick Tyler and Tom Iverson and the references used were mostly tribal biologists working on commercial harvest manager for each fisher's tribe. An additional three applications were received from you which brought the total to sixteen. The low score for one question from the reference questionnaire was dropped for each candidate and the total was added to the points scored from the technical evaluation to determine the six finalists. 5 pm, 15 May 1990, the six finalists were determined.

15-17 May 1990- Immediately we started contacting all 16 applicants and informing them whether or not they were selected. The final six were asked to bring their boat to Umatilla on 18 May 1990 for an evaluation. One of the six finalists was not able to be contacted, so after a great amount of effort by several individuals to contact him, he was dropped from the list.

Appendix C-4.

List of **equipment** supplied by UW for the 1990 experimental commercial northern **squawfish longline fishery** and approximate costs of each item

1 Manual longline reel with 1 spool	\$298.00
3 Replacement spools for manual longline reel @ \$48.00 each	144.00
1 Block for longline reel	10.00
.7500 Feet of 300 lb test monofilament groundline @ \$6.20 per pound	93.00
2500 Brass bead stops @ \$0.13 each (every three feet on groundline	325.00
750 Plastic one-piece gangion snaps @ \$0.29 each	217.50
3000 - 3/0 Kahle horizontal fishing hooks @ \$30.00 per 1000	90.00
2000 Feet of 30 lb test monofilament line for leaders	25.00
1000 Plastic beads for gangions	15.00
24 Saturn yellow Polyform A-O buoys @ \$10.00 each	240.00
24 Large Se&Dog caribeaner snaps @ \$1.68 each for each buoy	40.32
40 Large Sea-Dog caribeaner snaps @ \$1.68 each for buoy lines	67.20
25 Small Sea-Dog caribeaner snaps @ \$1.44 each for each longline	36.00
40 Halibut gangion snaps for anchors @ \$0.49 each	19.60
40 Anchors made of scrap metal averaging 10 lbs @ \$0.32 per pound	128.00
1 Crimping tool and 500 line sleeves	50.00
200 Fathoms of 1/4" poly-holobraid rope	45.00
1 Large cooler for holding bait and squawfish	70.00
Miscellaneous items such as hook removers, hook sharpeners, side cutter pliers, etc.	8638
Miscellaneous expenditures for welding and machine shop work, materials for gangion boards, and materials for installing equip.	500.00
TOTAL	\$2500.00

Appendix C-5.

Exit interview questions for participants in the 1990 Tribal **longline** fishery.

DRAFT

QUESTIONS FOR EXIT INTERVIEW WITH SQUAWFISH FISHERMEN

ADEQUACY OF GEAR AND ADVICE:

A. Longline reels (as modified), spools, fairleads, hook holders, gear, etc.:

Reels:	Poor _____	Okay _____	Good _____
Spools:	Poor _____	Okay _____	G o o d _____
Fairleads:	Poor _____	Okay _____	Good _____
Hooks:	Poor _____	Okay _____	Good _____
Line:	Poor _____	Okay _____	Good _____
Anc hors:	Poor _____	Okay _____	Good _____
Bouys:	Poor _____	Okay _____	Good _____

Comments for improvements of gear: _____

B. Bait: Poor _____ Okay _____ Good _____

Comments for improvement of bait: _____

C. Initial advice on fishing methods:

Poor _____ Okay _____ Good _____

Comments: _____

D. Support services during the fishing season, availability of extra equipment and advice, etc.:

Poor _____ Okay _____ Good _____

Comments: _____

E. Administrative support during fishing season:

Poor _____ Okay _____ Good _____

Comments: _____

Questions:

1. Describe any restrictions placed on your fishing that you feel limited your effectiveness on squawfish? _____

2. Which of these restrictions should be removed or modified to improve your efficiency on squawfish? _____

3. Did the ^{pressure}~~presence~~ of an observed aboard your boat affect your efficiency? If so, describe the problems. _____

4. Would you longline for squawfish in future years, at your own expense, if you were to receive only the \$4 bounty per fish?
Yes _____ No _____ Uncertain _____
or Yes with the following qualifications _____

5. Give any other comments, suggestion or criticisms of the squawfish longlining program in which you participated this season. _____

EXIT INTERVIEW
COMMERCIAL LONGLINE FISHERMEN
SUMMER 1990

Interviewer _____ Date _____ Fisherman _____

1. How long have you been fishing on the Columbia River?
2. What species do you normally fish for?
3. Did you use your regular crew to **fish** for squawfish?
4. Do you usually market your **own** fish or sell to a buyer?
5. Can you think of any market possibilities for squawfish?
6. If answer to **#5** is yes, what price do you think squawfish could sell for?
7. Do you think there is any potential for a commercial fishery for squawfish?
8. If answer to **#7** is yes, what do you think would be the best way to set up and operate the commercial fishery?

THANK YOU.

REPORT D

Columbia River Ecosystem Model (CREM) -- Modeling Approach
for Evaluation of Control of Northern Squawfish Populations Using
Fisheries Exploitation

Prepared by:

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Andrew F. Johnston
Center for Excellence in
Space, Earth and Life Sciences
Computer Sciences Corporation

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FINAL REPORT

COLUMBIA RIVER ECOSYSTEM MODEL (CREM) -- MODELING APPROACH FOR EVALUATION OF CONTROL OF NORTHERN SQUAWFISH POPULATIONS USING FISHERIES EXPLOITATION

Services Contract to BPA Project No. 90-077:
Computer Sciences Corporation Contract #01280

Introduction

The two objectives of this contract included tasks intended to result in 1) **seasonal**, reservoir specific projections of juvenile **salmonid** mortality in response to predator fisheries, and 2) long-term system-wide projections of mortality under various assumptions about exploitation intensity and compensatory predator regrowth. This report provides an estimate of the current season mortality changes resulting from 1990 predator fisheries and an estimate of the future effect of such fisheries if either terminated, continued or modified in intensity.

Objectives

Using various versions of the Columbia River Ecosystem Model (**CREM**), analyse data on fishing effort and catch levels from the various 1990 predator fisheries in the three lower Columbia River impoundments and make estimates for:

1. 1990 **salmonid** mortality in comparison with mortality in the absence of the predator fisheries;
2. future year **salmonid** mortality if fishing is continued or modified in intensity;
3. predator population changes resulting from the fishery.

Methods

The Columbia River Ecosystem Model, version 2.04, was described and documented completely by Bledsoe (1990). For the purposes of this study, version 2.04 was parameterised for three area simulations of each of the three lower Columbia impoundments, John Day, The Dalles and Bonneville reservoirs. The three areas simulated are the tailrace, reservoir proper and the downstream dam **forebay**. The relatively minor modifications to **CREM** v. 2.04 which are described in this section will be called version 2.1.

Passage numbers

Juvenile **salmonid** passage data through the counting facility at McNary dam for the summer of 1990 was provided by the Fish-Passage Center (FPC). Other information provided by the FPC was used to produce estimates of daily passage over the dam from the collector data. Since the passage data accounted only for those fish passing through the collector, the fish guidance efficiency (FGE) was used to estimate the number of fish arriving at the dam face. From this point the salmon could pass either through the spillway or into the turbine flow. A trial estimate was produced assuming that the relative proportions of fish taking these routes was the same as the relative proportions of the water flowing through the same routes. The daily collection figure was subtracted from the number of fish going through the turbines and turbine mortality figures from the FPC were applied to the remainder. Similarly, the spillway numbers were modified using the spillway efficiency and spillway mortality figures. The sum of the modified flows of fish from these two paths and of the reported bypass figures was taken as a trial estimate of the total passage. If this number was negative, the assumption that any salmon passed through the turbines was discarded and passage was recomputed assuming that all uncollected salmon passed through the spillway (applying appropriate efficiency and mortality figures) and that bypassed fish still re-entered the system as reported.

Passage data for the John Day and Dalles dams was generated from the simulations of the respective upstream forebays. In order to model the passage of **salmonid** smolts through the three reservoirs, the estimated migration from the **forebays** of John Day and the Dalles reservoirs, based on the **forebay** residence times for those regions (assumed to be one day), was used to provide daily figures for salmonids arriving at the upstream faces of the Dalles and Bonneville dams. The passage over these dams was assumed to take place with perfect efficiency, since collection did not occur at either of them; dam passage mortality is also assumed to be negligible.

The reason-for this method of- calculating passage into the two downstream reservoirs is that passage calculated from the data provided by FPC was extremely low, numbering in the hundreds of juveniles for the entire year. Passage into McNary Dam numbered in the hundreds of thousands to several **million** (for chinook sub-yearlings) over the season. The functional response curve used in **CREM** is not intended to be accurate and is not calibrated for the very low **salmonid** densities which would result if the FPC data were used for the simulation. Consequently, the mortality estimates in this report are conditioned upon the actual passage of juveniles into The Dalles and Bonneville reservoirs being of the order of magnitude predicted by the CREM

simulation of predation in John Day reservoir. The order of magnitude limitation is because the mortality estimates are very insensitive to the exact passage numbers. A 20% error in passage numbers would probably make a less than 1% error in the mortality estimate. Mortality estimates are much more sensitive to the timing of the runs and other factors such as the residence time for passage and spatial distribution of the predators relative to the prey.

These passage numbers were used for the 1990 simulation; for the simulation of years 1991 to 1995 the same passage time series was also used.

Functional response

The functional response curve used in previous reports of CREM simulations (Bledsoe 1990, Bledsoe et al 1990) were based on an assumption of strong preferential predation on **salmonid** smolts by northern squawfish. Data collected from a study of predator stomach contents reflect that preference in the **tailrace** of John Day reservoir (Vigg 1988 and unpublished data of Steven Vigg). The same study, however, suggested that non-salmonid species make up a high proportion of the prey in the rest of the reservoir. The asymptote of the functional response curve used for simulations in this study differs between the **tailrace** and the rest of the reservoir in order to reflect this change in maximum **salmonid** prey consumption. The functional response curve in a given region is **equal** to the curve used in the **tailrace** multiplied by an adjustment factor. This factor is the ratio of the observed proportion of **salmonid** prey species to total prey in the predator stomachs for predators sampled in the given region. Since the data regions are classified as from either the **boat-restricted zone (BRZ)** or the remainder of the reservoir, computations from the BRZ data are taken to be representative of the **tailrace** and those from the remaining data are taken to apply to **all other** areas of the reservoir..

Predator populations

Estimates of predator population sizes were based on the Beamesderfer and Rieman (1988) values for John Day reservoir. The 1990 electroshock catch rates in the different regions of John Day, The Dalles and Bonneville reservoirs were used as an index to relative predator densities in those regions. Electroshock catch rates in John Day reservoir served as the calibration for the index. Since CREM calculates population densities from total population numbers, the areas (m^2) for the various regions were scaled from navigation charts.

Catchability coefficients

CREM, Ver. 2.04 (Bledsoe 1990), will calculate **salmonid** mortality by species, reservoir area and time given a schedule of fishing effort, catchability coefficients of the gear types, predator population estimates and the standard driving functions of the model (salmonid passage numbers, temperature, dam flow etc.). Catchability coefficients are estimated as the value q , solved for in the equation,

$$C = q E N \quad 1$$

where C is total season catch, E is total season effort and N is average predator population density (numbers/square meter) during the simulated season. Catch and effort values were taken from Vigg and Burley (1990) and population densities were estimated as described above.

Following equation 1 of Bledsoe (1990),

$$Dt[P_n] = - (p_{mt} + p_q ef) P_{nl}, \quad 2$$

parameters p_q , catchability coefficient, and ef , fishing effort, are described as being indexed (i.e., subscripted) for predator species, for p_q , and predator species and reservoir area, for ef . Fishing effort is also, as a driving function of the model, variable with time. For CREM, version 2.1, p_q and ef are indexed on fishing gear type and the index for predator type has been dropped. This allows complete parallelism between the model and the actual fishery, which involved up to five different effort **types**, whereas simulations involving **multiple** predator species were not required for this study.

Repeated simulation with incremental adjustment of p_q values, starting with the initial values determined from equation 1, enabled determination of a set of values which made it possible to approximately simulate the observed total fish catch, and the time series pattern of catch. The pattern of catch was less accurately simulated than the total catch. Precise simulation of the observed time series of catch will depend upon use of the automatic parameter estimation procedure (CREM/PEP) as described in the text for this and the follow-on 1991 contract for this project. Mortality estimates made using the current method are approximately correct; the major advantage of use of the CREM/PEP is to make an accurate determination of the size, spatial and (possibly) temporal distribution of predator populations and other, critically sensitive ecosystem parameters (see Bledsoe et al 1990) such as **salmonid** residence times. Accurate determination of these values will provide for greater

credibility of and confidence in the **salmonid** mortality estimates made by CREM. Progress is currently being made in system parameter determination with the CREM/PEP, however description of those efforts is beyond the scope of this report.

Values for season catch and effort by area and gear **type** were taken from data collected from fishing efforts during the 1990 season (Vigg and Burley 1991). Initial population values were determined as described above. The total catch over all geartypes in each area was subtracted from the initial **population** and the seasonal average was then computed from the **initial** and final season values.

Reservoir model

The John Day and Dalles reservoirs were divided into three areas for the simulation. These were

- 1) the tailrace,
- 2) the reservoir proper, and
- 3) the **forebay** of the dam.

The Bonneville reservoir was divided into four areas by functionally splitting the **forebay** into

- 3) **forebay #1** and
- 4) **forebay #2**,

corresponding to the two separate powerhouses of Bonneville dam. This separation was made because of the separate characteristics of those two areas with respect to fish catch rates and suspected **salmonid** predation mortalities. Since the indexing data (electroshock) for predator catch was taken somewhat upstream from the dam and was not specific to one or the other **forebay**, no **"natural"** method was available to assign most of the **forebay** to one or the other powerhouse. The **modelled forebays** were assumed to be **equal** in area and to have the same electroshock indices. The dam angling efforts for each powerhouse were reported distinctly and were incorporated distinctly into the respective **forebays** of the model.

Results

Total passage in 1990 of juvenile salmonids over **McNary** Dam into John Day reservoir drove the simulations of all three lower Columbia impoundments. Values for the passage are given in Table 1.

Table 1. Total passage numbers of five species of juvenile **salmonid** into John Day reservoir over McNary Dam in 1990, as used to drive the **CREM** simulations of reservoir migration and predation for 1990 through 1995.

Species	Chinook sub-year.	Chinook yearling	Steelhead	Coho	Sockeye
Numbers (x 10 ⁶)	9.48	.784	.379	.177	.490

The simulations were driven by a time series consisting of the estimated daily numbers of each species to pass over McNary Dam.

The asymptotic value for the functional response curve in the reservoir was estimated to be 1.969. This is about 40% of the value in the tailrace (5.040) as reported by Vigg (1988) and as used for all reservoir areas in Bledsoe et al. (1990). All other parameters for the functional response curve are as reported in Bledsoe et al. (1990).

Squawfish population numbers in the various regions of the three reservoirs, based on electroshock catch rates calibrated against the Beamesderfer and Rieman (1988) estimates for John Day reservoir, are given in Table 2.

Table 2. **Squawfish** mean population number estimates and coefficients of variation (per cent, parentheses) for the simulated regions of the three Columbia River reservoirs. Coefficients of variation for the populations are based on the component of total variance contributed by variability in the electroshock catch rates and do not include the variability in the original Beamesderfer and Rieman (1988) estimate of population size in John Day reservoir.

Reservoir	Region			
	Tailrace	Reservoir	Forebay 1	Forebay 2
John Day	2800 (20.)	81098 (27.)	902 (35.)	(n/a)
Dalles	1950 (30.)	63100 (27 .)	580 (24.)	(n/a)
Bonneville	479 (14.)	297000 (12.)	1065 (192.)	1065 (192.)

The observed 1990 catches (Vigg and Burley 1990) were simulated within an error of 5% by the catchability coefficient values estimated for this study. The fishing effort levels (Vigg and Burley 1990) resulted in total and average instantaneous mortalities to the predator populations as shown in Table 3.

Table 3. Total mortality (per cent) and average annual instantaneous mortality rates (yr^{-1} , parentheses) for the squawfish predator populations in three lower Columbia impoundments.

Reservoir	Mortality
John Day	12.3 (-0.1311)
Dalles	19.7 (-0.219)
Bonneville	9.45 (-0.0993)

Simulation of six years of predator fishing similar in intensity and pattern to that which occurred in 1990 resulted in the salmonid mortality estimates shown in Table 4. Twice the 1990 fishing intensity for the five years following 1990 resulted in the mortality estimates shown in Table 5.

Table 4. Estimates of total annual mortalities due to predation of juvenile salmonids by northern squawfish in the Lower Columbia River. Numbers are based on simulations of **salmonid** migration and predator feeding by the Columbia River Ecosystem Model, version 2.1. Driving functions (passage numbers, fishing pattern) were based for all years on 1990 values. (a) John Day reservoir; (b) The Dalles reservoir; (c) Bonneville reservoir; (d) Total mortality due to passage of all three lower Columbia reservoirs.

(a)					
John Day Reservoir	Chin 0	Chin 1	Species Steel	Coho	Sockeye
1990	0.4960	0.3087	0.3266	0.3000	0.3285
1991	0.4605	0.2820	0.2961	0.2720	0.3019
1992	0.4253	0.2554	0.2664	0.2450	0.2754
1993	0.3914	0.2304	0.2389	0.2200	0.2502
1994	0.3593	0.2067	0.2134	0.1969	0.2264
1995	0.3289	0.1847	0.1899	0.1756	0.2039
(b)					
The Dalles Reservoir					
1990	0.4728	0.0334	0.0356	0.0361	0.0353
1991	0.4032	0.0274	0.0294	0.0300	0.0289
1992	0.3393	0.0225	0.0243	0.0248	0.0236
1993	0.2821	0.0184	0.0201	0.0205	0.0193
1994	0.2324	0.0151	0.0165	0.0169	0.0158
1995	0.1902	0.0123	0.0136	0.0139	0.0129
(c)					
Bonneville Reservoir					
1990	0.6531	0.1363	0.1253	0.1240	0.1319
1991	0.6492	0.1202	0.1104	0.1097	0.1153
1992	0.6460	0.1058	0.0975	0.0971	0.1010
1993	0.6414	0.0933	0.0862	0.0887	0.0887
1994	0.6340	0.0825	0.0767	0.0764	0.0785
1995	0.6248	0.0731	0.0680	0.0680	0.0693

Table 4. (cont'd.)

(d)					
Total					
1990	0.9078	0.4229	0.4319	0.4089	0.4376
1991	0.8871	0.3856	0.3922	0.3713	0.4002
1992	0.8656	0.3491	0.3540	0.3352	0.3640
1993	0.8433	0.3150	0.3185	0.3038	0.3299
1994	0.8200	0.2831	0.2857	0.2708	0.2984
1995	0.7961	0.2536	0.2553	0.2424	0.2686

Table 5. Estimates of total annual mortalities due to predation of juvenile salmonids by northern squawfish in the Lower Columbia River. Conditions are the same as for Table 4 except that twice the fishing effort was used for 1991 through 1995. (a) John Day reservoir; (b) The Dalles reservoir; (c) Bonneville reservoir; (d) Total mortality due to passage of all three lower Columbia reservoirs.

(a)					
John Day Reservoir	Chin 0	Chin 1	Species Steel	Coho	Sockeye
1990	0.4960	0.3087	0.3266	0.3000	0.3285
1991	0.4476	0.2806	0.2939	0.2700	0.3001
1992	0.3817	0.2312	0.2392	0.2203	0.2506
1993	0.3225	0.1874	0.1924	0.1779	0.2064
1994	0.2690	0.1500	0.1533	0.1422	0.1676
1995	0.2211	0.1187	0.1210	0.1125	0.1344

(b)					
The Dalles Reservoir					
1990	0.4728	0.0334	0.0356	0.0361	0.0353
1991	0.3919	0.0272	0.0291	0.0297	0.0287
1992	0.3045	0.0203	0.0218	0.0222	0.0214
1993	0.2324	0.0149	0.0161	0.0165	0.0159
1994	0.1739	0.0109	0.0118	0.0122	0.0116
1995	0.1278	0.0079	0.0086	0.0089	0.0085

Table 5. (cont'd)

(c)					
Bonneville Reservoir					
1990	0.6531	0.1363	0.1253	0.1240	0.1319
1991	0.6310	0.1196	0.1095	0.1088	0.1146
1992	0.5797	0.0957	0.0875	0.0873	0.0919
1993	0.5284	0.0758	0.0694	0.0717	0.0731
1994	0.4746	0.0598	0.0550	0.0551	0.0581
1995	0.4200	0.0469	0.0433	0.0435	0.0456

(d)					
Total					
1990	0.9078	0.4229	0.4319	0.4089	0.4376
1991	0.8622	0.3836	0.3892	0.3685	0.3978
1992	0.7768	0.3160	0.3178	0.3014	0.3312
1993	0.6948	0.2562	0.2565	0.2456	0.2721
1994	0.6139	0.2054	0.2052	0.1955	0.2209
1995	0.5351	0.1629	0.1626	0.1552	0.1770

Predator population estimates by the simulated fisheries for both the 1990 fishing intensity and twice the 1990 intensity (in 1991 through 1995) are given in Table 6. Though the model simulates population changes in each area of the reservoir, it also assumes that areas which are depleted of predators will be replenished by migration from adjacent areas if there are predators available. For this reason it is meaningless to show population estimates by area for the simulated years; the spatial distribution of predators in the reservoir is assumed to continue throughout the simulation.

Table 6. Population projections for northern squawfish in three lower Columbia reservoirs in response to predator fishing effort.

Numbers are reservoir totals at the beginning of the year except for the final column which is the population at the end of year 1995. (a) Projections based on continued fishing at 1990 effort levels; (b) projections if fishing effort is doubled for years 1991 through 1995.

<hr/>							
(a)							
Year							
Reservoir	90	91	92	9 3	94	95	Final 95
<hr/>							
John Day	85316	74614	65119	56836	49569	43202	37637
The Dalles	65630	52753	42381	34037	27309	21900	17543
Bonneville	299609	265797	235524	208430	184094	162375	142815
<hr/>							
(b)							
John Day	85316	74614	57480	44283.	34122	26290	20256
The Dalles	65630	42402	27367	17652	11363	7308	4689
Bonneville	299609	235801	185147	144999	113116	88000	68076
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Discussion

It is apparent that very little immediate improvement in reduced mortality to juvenile salmonids can be expected. This is due to the fact that the predators removed in 1990 are still active in the reservoir for part of the year. However some slight effect can be seen in 1991 (theoretically) even if no further fishing occurs, and after five years of effort the theoretical prediction is for a substantial reduction, **33%**, to the most vulnerable young-of-the-year chinook in John Day reservoir. In contrast to this considerable reduction, the overall reduction in mortality for passage through all three reservoirs is only 12% for sub-yearling chinook. If fishing effort is doubled in 1991 through 1995, the first year 91% mortality is reduced to 54% (Table 5d and 6d), a reduction of 41%.

An overall mortality of 54% for sub-yearling chinook is still unacceptably high. As pointed out in Bledsoe et al (1990, Figure 7), this very high mortality is due to the prolonged residence time during outward migration. By contrast the other four species spend only 20% as much time (approx. 4 days vs. 20 days) in John Day reservoir and are therefore subject to much lower predation levels. If other mitigating factors for sub-yearling mortality cannot be **found**, it would be possible to reduce the total mortality by increasing the predator fishing intensity or continuing it for longer than the six years projected in this study. Projecting the results in this study, and assuming that the conditions of these simulations are approximately realistic, in order to drop overall mortality to 10% it would be necessary to continue the doubled fishing intensity level for 21 years. Alternatively an increase of six to seven times the 1990 fishing intensity would reduce overall mortality to 10% by 1995.

During the latter years of either program the squawfish population would drop to a very low level-and it might be difficult to sustain interest in a sport reward fishery due to low catch rates. Conversely however, catch rates might remain reasonably high in a dam angling fishery in certain locations. The catch rates at Bonneville **forebay**, powerhouse #1 resulted in over 17,000 fish in 1990 and the electroshock based populations estimates for the entire **forebay** were only about 2,000 fish. This is only possible if there is a considerable influx of fish from other areas replacing those which are caught, as is assumed in the **CREM** simulations.

A critical assumption in these simulations is the total size of the predator population in John Day reservoir. This has been assumed to be 85,316, as estimated by Beamesderfer and Rieman (1988). Confidence intervals for this population value are quite broad and a number of professionals have expressed the view that the actual population may be much larger (3x - 8x). If the population is larger, then the mortality estimates may also be larger, though **CREM** simulations would have to be recalibrated with the population assumptions to confirm this. Another implication of a larger predator population is that the impact upon mortality reduction of a given effort level in the predator fishery would be smaller, i.e. the annual decreases in mortality in Table 4 would be smaller. The annual decrease in the catch for a given effort level would also be smaller.

These conclusions are critically dependent upon the assumption of zero net population regrowth. A simulation of the situation under regrowth was not made because of the wide range of assumptions which might be made. If we assume that the squawfish have an age distribution which is approximately stable over, say, ten years, then the annual regrowth in the absence of fishing mortality exactly balances the natural mortality and the population has no long term trend up or down. Under this "**neutral**" assumption, the youngest age class of **predator**-sized fish would be the largest. Using the assumptions of a declining annual mortality (which are made in the data set used for **CREM**, Ver 2.05, see Bledsoe 1990) the size of the incoming five year old age

class is 23% of the predator population, or about 19,500 fish. The results shown in Tables 4 and 5 are a **"best case scenario"**, in which zero of the incoming cohort of 19,500 results in net positive population growth. A **"worst case scenario"** would result in all 19,500 adding to the population, balanced against 10,000 (John Day reservoir) removed by the fishery. Obviously, no improvement in mortality would result; rather the contrary. A **"neutral case"** might be that the elimination of 10,000 predators makes room for compensatory growth approximately equal and no net decrease or increase in the population results from the fishery. The only effect would be to slightly lower the average age and, presumably, size as well. This might be expected to have a marginally beneficial effect on mortality. The only way to determine whether compensatory growth is or will occur is to accurately measure both the population density and to monitor the size structure of the fishery. The first effects will probably not be detectable for several years, if they occur at all, due to the large sampling variability in such measurements.

Finally, the mortality estimates in this report might be compared to those in Bledsoe et al (1990). The sub-yearling mortalities are slightly lower (50% rather than 64%) and this can be attributed to the use of an altered functional response curve which takes into consideration the more variable diet of squawfish in the reservoir relative to the tailrace. Although lower, the mortality is not as much lower as might be expected since the maximum consumption rate was reduced to 40% of its earlier value. This non-linear effect is reasonable because of the non-linear nature of the functional response curve. Since the average per-capita consumption in the reservoir is about 0.5 salmonids per day, this indicates that the average squawfish is operating in the curvilinear rather than the asymptotic part of the functional response where non-linear effects might be strongest. The other four **salmonid** types indicated higher mortalities in the 30% range, rather than 10% to 25%. This can be attributed to the fact that the earlier simulations ignored the effect of transportation of smolts at John Day Dam and the passage driving files used for Bledsoe et al (1990) had about five times as many **juveniles passing** over the dam. This would tend to make the functional response operate in the asymptotic part of the curve more often and would give a **"swamping"** effect, actually decreasing mortality with an increase in passage numbers. This effect was shown in Bledsoe et al (1990) with a simulation experiment. Conversely, however, a reduction in passage numbers would be expected to result in increased mortality. Though the mortality rate is increased, the total number of salmonids consumed by predators is greatly decreased due to the transportation, however. Mortality rate is not the only measure of predator effect which should be used to judge performance of the system.

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**DEVELOPMENT OF A SYSTEM-WIDE PREDATOR CONTROL PROGRAM:
STEPWISE IMPLEMENTATION OF A PREDATION INDEX PREDATOR CONTROL
FISHERIES AND EVALUATION PLAN IN THE COLUMBIA RIVER BASIN**

Annual Report
April - December 1990

Prepared by

Anthony A. Nigro

Oregon Department of Fish and Wildlife

Cooperators
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University of Washington

Prepared for

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P.O. Box 3621
Portland, OR 97208-3621

Project No. 90-077
Contract Number **DE-B179-90BP07084**

December 1990

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IMPLEMENTATION OF A PREDATION INDEX, PREDATOR CONTROL FISHERIES,
AND EVALUATION PLAN IN THE COLUMBIA RIVER BASIN

Annual Report

April - December 1990

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COMMERCIAL **LOGLINE FISHERMEN**
SUMMER 1990

Interviewer _____ Date _____ Fisherman _____

1. How long have you been fishing on the Columbia River?
2. What species do you normally fish for?
3. Did you use your regular crew to fish for squawfish?
4. Do you usually market your own fish or sell to a buyer?
5. Can you think of any market possibilities for squawfish?
6. If answer to #5 is yes, what price do you think squawfish could sell for?
7. Do you think there is any potential for a commercial fishery for squawfish?
8. If answer to #7 is yes, what do you think would be the best way to set up and operate the commercial fishery?

THANK YOU.

Development of a System-Wide Predator Control Program: Stepwise Implementation of a Predation Index Predator Control Fisheries and Evaluation Plan in the Columbia River Basin.

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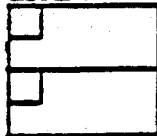
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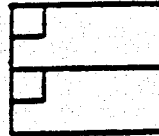
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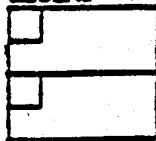
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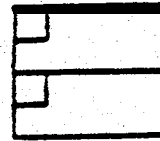
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